

FINAL

**PLAN FOR PREVENTION OF
CONTAMINANT DISPERSION**

Version B

**U. S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado**

ENVIRONMENTAL RESTORATION PROGRAM

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By F. J. Curran *11-11-91*

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	iv
ACRONYMS	vi
1.0 INTRODUCTION	1
1.1 Background	1
1.2 Scope and Application	3
1.2.1 PPCD Applicability	3
1.2.2 Baseline Risk Assessment	6
1.2.3 Feasibility Studies	7
1.2.4 PPCD Implementation	8
2.0 THE PLAN FOR PREVENTION OF CONTAMINANT DISPERSION	14
2.1 Specific Components of the PPCD	14
2.1.1 Establish Soil Threshold Levels	14
2.1.1.1 Emission Scenarios	15
2.1.1.2 Step by Step Process Explanation	19
2.1.2 Preventive Measures Assessment	21
2.1.2.1 Major Excavations	23
2.1.2.2 Minor Excavations	23
2.1.2.3 Drilling	23
2.1.2.4 Unpaved Roads	23
2.1.3 Monitoring Requirements	24
2.1.3.1 RFI/RI Monitoring Program	24
2.1.3.1.1 Stage 1 Monitoring	26
2.1.3.1.2 Stage 2 Monitoring	26
2.1.3.1.3 Work Start/Stop Criteria	27
2.1.3.2 Nonradioactive Ambient Air Monitoring ..	27
2.1.3.3 Radioactive Ambient Air Monitoring	27
2.1.4 Implementation Plan	28
2.1.4.1 PPCD Step by Step Breakdown	30
2.2 Example PPCD Demonstration - 881 Hillside Monitoring Well Installation	33
2.2.1 Rocky Flats Plant Area Location	33
2.2.2 Scenario Identification	34
2.2.3 Emission Rate Estimation	34
2.2.4 Identification of Principal Contaminants (OU Specific Data)	35
2.2.5 Soil Threshold Selection Process	37
2.2.6 Soil Data Comparison with Threshold Levels	37

2.2.7	Mitigation Measure Identification	40
2.2.8	Monitoring Program Initiation	40
2.2.9	Documentation Requirements	40
2.3	Administrative Procedure for the EG&G Project Manager	41
2.3.1	Key Personnel Position Description/Organizational Chart	43
2.3.2	Quality Assurance/Quality Control	45
2.3.3	Records Management	46
3.0	REFERENCES	48

APPENDICES

Appendix 1	Principal Contaminants
Appendix 2	Estimation of Emission Rates
Appendix 3	Dispersion Calculation
Appendix 4	Risk Calculations
Appendix 5	Calculation of Soil Threshold Levels
Appendix 6	Dispersion Prevention Techniques
Appendix 7	Air Monitoring Requirements
Appendix 8	Interim Plan for Prevention of Contaminant Dispersion

EXECUTIVE SUMMARY

The Plan for Prevention of Contaminant Dispersion (PPCD) is a "primary document" specified under the Interagency Agreement (IAG) between the Environmental Protection Agency (EPA), the Colorado Department of Health (CDH), and the Department of Energy (DOE) Rocky Flats Operations.

The technical scope of work as presented in the IAG has two primary functions: (1) The PPCD shall provide a management plan to prevent airborne transport of hazardous or dangerous materials; and (2) The PPCD shall include a proposal to evaluate the potential for and risk of windblown contaminants from the Rocky Flats Plant (RFP).

The applicability of the PPCD to intrusive field activities conducted as part of a RCRA Facility Investigation/Remedial Investigation (RFI/RI) or Interim Remedial Action (IM/IRA) consists of four key components: (1) establishment of soil threshold levels, (2) assessment/selection of preventive measures, (3) establishment of a monitoring plan, and (4) development of an implementation plan.

The PPCD presents criteria for designating intrusive RFI/RI or IM/IRA activities at site locations as Stage 1 or Stage 2. Risk-based soil thresholds for contaminants are derived as a function of activity to be conducted and distance from the site boundary. The application of these soil thresholds is based on public protection criteria; however, implementation of the required control measures and airborne monitoring will ensure that the workers are protected as well.

Activities conducted under Stage 1 are performed at site locations which have soil data indicating contaminant concentrations do not exceed the established soil thresholds. The Stage 1 contaminant dispersion control measures will include the following: establishing wind speed thresholds, water spray soil applications, waste pile

covering, and general administrative control measures such as vehicular speed limitations. The effectiveness of such controls will be measured by occupational health and safety real-time particulate and vapor monitors, soil moisture gauges, and anemometers.

Activities conducted under Stage 2 are performed at locations where RFI/RI intrusive activities such as IM/IRAs will require additional preventive measures and airborne contaminant monitoring. The Stage 2 dispersion control measures will consist of Stage 1 methods plus additional suppression techniques such as extensive wetting, wind screens, spray curtains or paving. The selection of any particular technique will depend on the activity performed and the effectiveness and/or implementability of the technique under consideration. In addition to real time monitoring, air sampling will provide an integrating record of the dust concentrations during the work activities.

Site-specific implementation plans and monitoring programs will be developed to verify proper execution and effectiveness of the control measures applied. Work will cease when the monitoring indicates unacceptable airborne concentrations of contaminants. Work will only resume these concentrations have been reduced to acceptable levels.

The PPCD has been developed through a working committee consisting of representatives from EPA, CDH, DOE, and EG&G. The technical approach and compliance measures that form the basis of this document were jointly discussed through a series of working group sessions.

ACRONYMS

ALARA	As Low As Reasonably Achievable
APR	Air Programs Representative
BRA	Baseline Risk Assessment
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
PC	Contaminant of Concern
DAC	Derived Air Concentration
DOE	Department of Energy
EM	Environmental Management
EMAD	Environmental Monitoring and Assessment Division
EPA	Environmental Protection Agency
FS	Feasibility Study
H&S	Health and Safety
HEAST	Health Effects Assessment Summary Tables
HSC	Health and Safety Coordinator
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
IPPCD	Interim Plan for Prevention of Contaminant Dispersion
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
NAAQS	National Ambient Air Quality Standard
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PEL	Permissible Exposure Level
PPCD	Plan for Prevention of Contaminant Dispersion
QA	Quality Assurance
QAO	Quality Assurance Officer
RAAMP	Radioactive Ambient Air Monitoring Program
RfC	Reference Concentration
RfD	Reference Dose
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
ROD	Record of Decision
RP	Remediation Program
SF	Slope Factor
SOP	Standard Operating Procedures
SSHSP	Site-Specific Health and Safety Plans
STL	Soil Threshold Level
TLV	Threshold Limit Value
TSP	Total Suspended Particulate
USDHHS	United States Department of Health and Human Services
VOC	Volatile Organic Compound

1.0 INTRODUCTION

1.1 Background

The Rocky Flats Plant (RFP) is a federally owned nuclear weapons research, development, and production complex situated on 6,550 acres of federal property 16 miles northwest of downtown Denver, Colorado. The plant is managed and operated by EG&G Rocky Flats, Inc. (EG&G), a contractor to the U.S. Department of Energy (DOE). In August of 1990, the State of Colorado, the Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH) entered an agreement with the U.S. Department of Energy (DOE) to ensure thorough investigation and appropriate response actions to environmental impacts and to ensure compliance with the Resource Conservation and Recovery Act and the Colorado Hazardous Waste Act. Under the terms of the Interagency Agreement (IAG), the site is broken into 16 operable units (OU) containing 178 Individual Hazardous Substance Sites (IHSS). Each IHSS has a unique set of contaminants ranging from a single hazardous substance to multiple potential contaminants (radionuclides, volatile organics, metals, and semivolatiles).

The Plan for Prevention of Contaminant Dispersion (PPCD) is a primary document mandated by the IAG. The general guidance provided in the IAG led to several draft versions of the PPCD.

The PPCD purpose was clarified to address the wording of the IAG:

The PPCD shall provide for the management of wastes associated with sites in such a manner as to prevent windblowing of hazardous or dangerous materials through techniques such as soil cover over hazardous and dangerous materials and/or use of appropriate wetting techniques which DOE shall include as part of the Plan, a proposal to evaluate the potential for and risk of windblown inorganic, radioactive, and organic hazardous constituents released from sites at the Rocky Flats Plant. . .

The PPCD draft version 1.0 was reviewed by the Colorado Department of Health (CDH) and the Environmental Protection Agency (EPA) Region VIII. The review resulted in a revised approach to develop a more project-specific plan with a defined purpose. A working group was formed to jointly develop a document addressing the intent of the IAG PPCD. The working group consisted of representatives from the following organizations: Colorado Department of Health (CDH), EPA, DOE, and EG&G. Approximately every three to four weeks, meetings were held to discuss the technical approach to fulfilling the purpose of the PPCD.

Upon review of the initial PPCD Draft (Version 2.0) EPA commentors (EPA/CDH 1991) recommended the following:

An acceptable Plan will institute appropriate standards and procedures, establish monitoring programs to verify the effectiveness of implementation procedures, establish decision processes, and specify actions that will be taken based on those decisions.

The clarification of the PPCD purpose was provided during the working group meetings. This plan, addressing the above-stated purpose in an easy to follow manner, will ensure that the public is protected by a site- and contaminant-specific plan to evaluate and prevent unacceptable hazards resulting from windblowing of hazardous or dangerous materials.

The PPCD has been organized in the following manner: Section 2.0 contains the entire plan in three subsections and includes a synopsis of the appendices. Section 2.1 provides the specific components of the PPCD. Section 2.2 includes a specific example of how the PPCD is intended to work. Section 2.3 describes the administrative responsibilities for executing the PPCD. The appendices which follow include the calculations, assumptions, and conclusions which contain significant information to support the various aspects of the PPCD. The document has been written for the lay public as well as the direct users.

This document has been developed from a working group approach and is considered to be a "final PPCD". A final responsiveness summary addressing public comments will be developed after the public has had an opportunity to thoroughly evaluate and publicly comment as stated in the IAG. The RFP Community Relations Plan will be the means for public involvement, awareness and communication regarding the approval and implementation of the PPCD.

1.2 Scope and Application

The PPCD has been developed to ensure that the public is protected from the potential increased health risk associated with inhaling windblown hazardous or dangerous constituents from RFP. Several other federally mandated studies involve a similar scope of work; however, each study is directed at a specific stage of the RFI/RI process. The scope of the PPCD is to address the potential off-site public health hazards resulting from intrusive actions occurring during the RCRA Facility Investigation/Remedial Investigation (RFI/RI) and Interim Remedial Action (IM/IRA) activities. Protection of on-site populations, such as plant site general workers, is addressed under the RFP site-wide Health and Safety Program. Section 1.2.1 describes the applicability of the PPCD and further clarifies the document's scope.

1.2.1 PPCD Applicability

The PPCD is applicable to intrusive field activities conducted as part of a RFI/RI field investigation or IM/IRA. The RFI/RI field investigation refers to the RCRA/CERCLA-SARA investigation, remedial action alternatives assessment, and remedial action process. The investigation phase of an RFI/RI includes the test pits and drilling phases, etc. This process includes activities such as preparation of workplans and health and safety plans, conducting RFI and RI field studies, evaluating potential public and environmental health impacts through Baseline Risk

Assessments (BRAs), analyzing remedial action alternatives through completion of Feasibility Studies and Corrective Measures Studies, and obtaining a Record of Decision (ROD), as well as remedial design, remedial action (RD/RA) and compliance verification. The RFI/RI phase of this process includes activities directed at hazardous waste site investigation. For purposes of the PPCD, Interim Remedial Actions (IM/IRAs) are also considered.

Table 1 identifies three specific stages of intrusive field activities that could occur during the RFI/RI process at RFP. Table 1 also identifies three populations of human receptors that could potentially be exposed to site related contaminants released during intrusive activities. Following is a brief functional description of these stages and populations:

Table 1

	REMEDIAL INVESTIGATION/ INTERIM REMEDIAL ACTIONS (IM/IRA) PERIOD	NO ACTION PERIOD	REMEDIAL ACTION PERIOD
OFFSITE (PUBLIC)	PPCD	Baseline Risk Assessment	FS Risk Assessment
PLANT SITE GENERAL WORKERS	Site-Specific H&S Plan	Baseline Risk Assessment	FS Risk Assessment
REMEDIAL WORKERS	Site-Specific H&S Plan	Site-Specific H&S Plan	FS Risk Assessment

- Remedial Investigation/Interim Remedial Action Period. During this period of RFI/RI activities, investigation-driven intrusive activities are being performed at the site. Such activities include: borehole and monitoring well installation and small scale excavation such as test-pit installations. Additionally, as indicated above, IM/IRAs may be conducted during this period. The latter are expected to result in higher emissions than RFI/RI activities. Overall, the emissions generated from the Remedial Investigation/ Interim Remedial Action activities at the RFP are expected to be relatively small compared to large-scale remediation projects.

- **No Action Period.** This segment of the RFI/RI process comprises periods when no intrusive field activities are being conducted; thus, contaminants are not being released as a result of such activities. Releases due to other actions or circumstances discovered during No Action periods will be addressed through initiation of IM/IRA's, as necessary to alleviate threats to public health or the environment.
- **Remedial Action Period.** This period of activity occurs after approval of the Proposed Remedial Action Plan and signing of the ROD. The remedial action period includes remedial design and remedial actions, and is often characterized by large-scale construction, earth-moving, and other heavy mechanized actions related to cleanup. Generally, emissions generated as a result of these activities will be of considerably greater magnitude than those associated with the Remedial Investigation/Interim Remedial Action Period.
- **Off-Site Public.** This population of potential receptors is the general off-site public who could be exposed to emissions from intrusive RFI/RI activities. For purposes of this assessment, this population is conservatively assumed to live at the RFP site boundary.
- **General Plant Workers.** RFP workers involved in production, plant support, and any other nonenvironmental restoration job activities are considered General Plant Workers.
- **Remediation Workers.** Environmental restoration workers comprise the population in this category. This includes workers involved in any stage of the environmental restoration program.

Inspection of Table 1 indicates that the hazards to the three potentially exposed populations during the no action stages, with the exception of remediation workers, will be evaluated in the BRAs. BRAs are required under the IAG for each OU as part of the RFI/RI report. Potential hazards to each of the three potentially exposed populations as a result of implementing remedial action alternatives will be evaluated as short term impacts in the detailed analysis of alternatives risk assessments in the Feasibility Studies. EPA Guidance requires that short-term impacts of remedial action be evaluated as one criterion in the Feasibility Study (EPA, 1988). The PPCD addresses the potential hazards to the site boundary public resulting from intrusive activities during the Remedial Investigation/Interim Remedial Action Stage. Site-specific Health and Safety Plans (SSHSPs) will address potential worker hazards associated with intrusive activities conducted during the Remedial Investigation/Interim Remedial Action Stage.

As indicated by Table 1, the hazards to plant site general workers as well as remediation workers will be addressed in the individual OU SSHSPs. Note that the PPCD and SSHSPs share the issue of worker health and safety. The PPCD draws heavily from the SSHSPs in establishing acceptable exposure levels for workers and in the establishment of monitoring requirements.

The following paragraphs have been included to provide a clear explanation of the various studies required to evaluate the risk of contaminant wind dispersion. The general focus of each study has been presented below.

1.2.2 Baseline Risk Assessment

Individual hazardous substance sites at RFP have been grouped into 16 OUs. A Baseline Risk Assessment will be conducted for each OU (IAG 1991) to evaluate the potential threat to the health and environment of potential receptors: the plant site general workers and the general public during the No Action Period.

The basic elements of the Baseline Risk Assessment are data evaluation, exposure assessment, toxicity assessment, and risk characterization. During the data evaluation phase available information on the hazardous substances located at each OU will be screened to identify principal contaminants. The exposure assessment will identify the point of potential contact with the principal contaminants and the exposure route at that point. In the toxicity assessment stage, the following factors will be considered: the types of adverse health effects associated with individual and multiple contaminant exposures; the relationship between the magnitude of exposures and adverse effects; and the related uncertainties. The risk characterization will identify the potential exposure to the receptors and evaluate the potential effects impacting the off-site public and on-site workers associated with such exposures.

Currently, risk assessments are planned for the 16 OUs under the no action condition. The risk from windblown contaminants will be assessed for each OU in accordance with the Risk Assessment Guidance for Superfund; Volume 1, Human Health Evaluation Manual (Part A).

1.2.3 Feasibility Studies

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires a remedial investigation and feasibility study for each facility included on the National Priorities List. The IAG among EPA, DOE, and the State of Colorado established the requirements for the performance of a feasibility study for each OU at RFP in order to identify, evaluate, and select alternatives for the appropriate remedial action to prevent, mitigate, or abate the release of the principal contaminants. At this time, feasibility studies are only beginning to be developed. Much of the necessary data required for these studies is generated in the Remedial Investigation phase described in the next section. The feasibility study process has four basic components:

1. development of alternatives for remediation;
2. screening of alternatives;
3. detailed analysis of alternatives; and
4. selection of preferred alternative(s).

In the analysis of alternatives, each alternative will be individually evaluated to determine whether it will adequately protect the health of the identified receptors. The alternatives will then be compared using established criteria to select an appropriate remedy. One evaluation criterion is short-term effectiveness. Assessment against this criterion examines the effectiveness of the alternatives during implementation of the alternative under consideration. Factors addressed under this criterion are: protection of the community during remedial actions; protection of workers during remedial actions; environmental impacts; and time until the remedial action objectives are achieved. This evaluation will consider the potential impacts associated with conducting a remedial action program weighing the results against the benefits. Each feasibility study will include an evaluation of the measures to be taken to protect the public and the surrounding environment from windblown hazardous and/or dangerous constituents that may result from remedial actions. The IAG instructs the DOE to "prepare RCRA Facility Investigation/Remedial Investigation Reports which will include the Baseline Risk Assessment results...and shall be developed using the RCRA Facility Investigation Guidance (Interim Final), and the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, October 1988" (EPA 1988).

1.2.4 PPCD Implementation

The PPCD will be applied primarily by the Project Manager (PM) during remedial investigations such as monitoring well installations, test pit excavation, and other larger dirt moving applications. Along with the PPCD, the PM will use the EPA/CDH approved site-wide Standard Operating Procedures (SOPs). The SOPs

contain specific procedures for General Equipment Decontamination and many other field operations, groundwater, geotechnical surface water, and ecology operations. These are additional procedures that are intended to guide the PM.

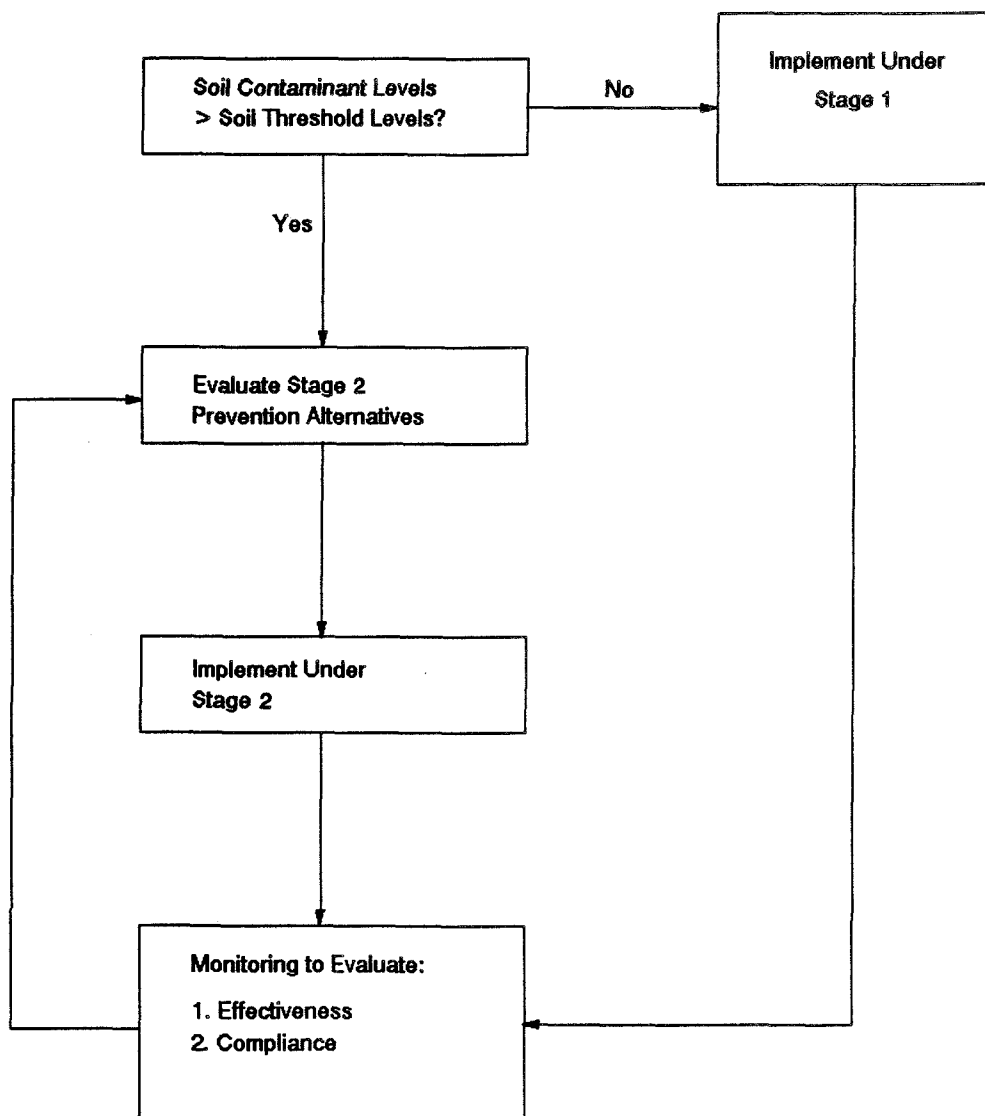
Besides guiding field activities, the PPCD outlines the necessary steps which shall be taken to "evaluate the potential for and risk of windblown inorganic, radioactive and organic hazardous constituents released from sites of the Rocky Flats Plant" (IAG, 1991). The PPCD includes specific procedures that 1) establish soil threshold levels, 2) determine the dust emission mitigation required when concentrations are in excess of the thresholds (Stage 2 areas), and 3) establish a monitoring program that will evaluate the effectiveness of dust control measures.

The PPCD uses simple airborne exposure and risk assessment techniques to evaluate the effectiveness of dust control measures. An emission model is used to predict the rate at which contaminants are released into the air from a source, and a dispersion model predicts associated concentrations in air at receptor points. A complete modeling set (see Appendices 2 through 6) will permit the PM to evaluate the potential for off-site impacts resulting from intrusive activities and guide the PM in selection of appropriate dust control measures.

The PPCD references the most current information in determining the uptake concentration of a hazardous substance that would result in an increased lifetime excess cancer risk or noncarcinogenic health effects. The methodology for obtaining this information and the specific application of how the toxicological data are used is discussed in Appendix 1 - Principal Contaminants.

The application of the PPCD monitoring program coincides with the health and safety monitoring program currently being enforced at RFP. The primary purpose of the monitoring program is to provide real-time monitoring to verify that emissions resulting from intrusive activities are within acceptable guidelines. Figure 1

FIGURE 1
IMPLEMENTATION OF THE PPCD



depicts a flow diagram which outlines the key decision making process in executing the PPCD. Activities conducted under Stage 1 are those activities performed at site locations which have site data indicating soil contaminant concentrations do not exceed the established risk-based soil thresholds. Activities conducted under Stage 2 are those activities performed at locations where RFI/RI intrusive activities such as IM/IRAs will require additional monitoring surveillance and preventive measures. The Stage 1 contaminant dispersion control measures will include the following: wind speed measurements, water spray applications, moisture testing, waste pile covering, occupational health and safety monitoring using real-time total suspended particulate capabilities, and general administrative control measures such as vehicular speed limitations are detailed in the Interim Plan for Prevention of Contaminant Dispersion (IPPCD, Appendix 8). The Stage 2 preventive measures consist of Stage 1 methods plus additional suppression techniques such as surfactants, enclosures, etc. Each Stage has a specific monitoring program and implementation plan that verify proper execution.

Using existing data, the PM will determine if the OU specific (possibly IHSS specific) contaminant concentration levels in soil are above the derived soil threshold levels. Soil threshold levels have been calculated based on gaussian plume dispersion (provides the dust concentration at the site boundary) and intake factors based on toxicity values obtained from EPA sources. Appendix 1 provides a discussion of selection of PCs. Appendix 2 discusses the intrusive activities considered. Appendix 3 discusses the dispersion model and the calculation of soil threshold levels (summarized in Appendix 5). Appendix 4 discusses the performance criteria and intake factors used.

It is expected that the soil being disturbed by intrusive field activities associated with the RFI/RI field investigation or IM/IRA normally will have contaminant concentrations below the soil thresholds. The PPCD then instructs the

PM to implement the intrusive activity under Stage 1 monitoring and dust suppression programs.

The Stage 1 monitoring and dust suppression programs encompass normal day to day health and safety monitoring requirements. This is supported by the RFP Environmental Restoration SOPs, Sitewide H&S plans, OU-specific H&S plans, and the subcontractor site H&S plans. Appendix 7 (Monitoring) discusses the specific procedures and instrumentation requirements. To assist the PM in his assessment of the need to implement dust suppression techniques, wind speed monitoring (with shutdown criteria 15 or 35 mph, depending on the intrusive activity) and occupational real-time air monitoring will be conducted. As a minimum, the following dust suppression techniques will be performed/enforced for those activities categorized as Stage 1:

- soil wetting
- soil covering during non-work periods
- vehicular traffic restrictions

The procedure for application of these measures is listed in the IPPCD (Appendix 8). As discussed previously, the IPPCD will serve as interim guidance until the PPCD is approved in final form. The joint working group of EPA/CDH/DOE/EG&G has reviewed and approved the IPPCD for interim use.

If soil contaminant concentrations are above the soil threshold concentrations, Stage 2 becomes applicable. The first step performed is the evaluation of Stage 2 prevention alternatives. Appendix 6 - Dispersion Prevention Techniques provides a detailed comparison of alternatives to be considered prior to startup. Stage 2 prevention alternatives provide for dust control and contaminant monitoring over and above that normally applied at RFP (i.e., Stage 1).

The remedial investigation or interim remedial action activities would begin upon completion of the Stage 2 evaluation of dust prevention alternatives. This phase of the Stage 2 implementation process may take significant setup time and could result in significant expenditure of resources. The PM will make the field decision of which alternative will be implemented and when it is fully operational before beginning intrusive activities.

Stage 1 and 2 have specific monitoring requirements to verify acceptable airborne contaminant concentration levels both to the on-site workers and the potential off-site receptor. Monitoring requirements under Stage 1 incorporates on-site soil moisture, total suspended particulate, and other meters (OVA, HNU) as deemed appropriate by the site Health and Safety (H&S) officer. The on-site real-time instrumentation will provide the information necessary to evaluate the adequacy of Stage 2 prevention measures and to verify that the on-site workers are operating under acceptable conditions under Stage 1.

2.0 THE PLAN FOR PREVENTION OF CONTAMINANT DISPERSION

2.1 Specific Components of the PPCD

This section of the PPCD will describe how the plan was developed and what assumptions were used to evaluate the risk of windblown contaminants. The PPCD was organized around four major tasks:

- 1) Establish soil threshold levels;
- 2) Conduct a preventive measures assessment;
- 3) Establish monitoring requirements; and
- 4) Develop implementation plan.

These tasks were identified through a series of meetings with the EPA/CDH/DOE/EG&G representatives. The technical focus was jointly developed based on comments received from earlier PPCD versions and public information needs as witnessed in previous public comment periods. This draft of the PPCD has been written in a manner that explains the technical approach in a concise, easily understood, uniting style. Supporting data is found in a series of appendices along with a step by step approach to developing each task.

A brief explanation of the individual task objectives and methodology is discussed in the following sections.

2.1.1 Establish Soil Threshold Levels

The RFP has a potential for numerous remedial investigation activities occurring at the same time with varying emission factors. In order to simplify and ensure PPCD application, soil threshold levels have been established for three modeling zones (A, B, and C) at RFP (see Drawing 1). An additional modeling zone

was chosen for Operable Unit 3 (OU3) for off-site releases (Drawing 2). OU3 includes Individual Hazardous Substance Sites 199 (Contamination of the Land Surface), 200 (Great Western Reservoir), 201 (Standley Reservoir), and 202 (Mower Reservoir). Each area has a number of emission activities at various points within the modeling zones. A specific modeling point has been conservatively selected on the wind vector having the highest frequency (1990 Rocky Flats Wind Rose, in Appendix 3) with a location in the middle of the zone (Zone A and OU3) or at the boundary nearest to the receptor (Zone B and C). Additional conservatism was introduced into the modeling of exposure by assuming that human receptors are closer to the emission source than they actually are. The modeling zones were designated based on OU-specific workplans and remedial investigation schedules. Modeling Zone B contains the majority of remedial investigation activities planned over the next five years (IAG scheduled final Field Activity Finish, January 1997); Modeling Zone A contains the most acreage and Zone B contains the site buildings and perimeter security zone.

Emission scenarios under the scope of the PPCD were narrowed down to the specific activities that may produce appreciable amounts of fugitive dust. Those activities needed to be broad based in order to cover the range of RI and IM/IRA activities proposed over the next five years. It has been assumed that during the next five years, most of the RI type activity will occur, and the Remedial Action Stage will become the primary reference for intrusive activities in the following five years.

2.1.1.1 Emission Scenarios

The following scenarios were used for general descriptions of dust producing RFI/RI type activities (see Appendix 6 for details of each of the scenarios described; Appendix 2 introduces emission factor models applied to the scenarios):

- (1) Major Excavations: activities involving earthmoving activities such as using scrapers and backhoes with large buckets. Typically hundreds of cubic yards of soil are handled in these types of activities. Example: 881 Hillside Phase II, B, Interim Remedial Action Project.
- (2) Minor Excavations: smaller construction projects involving a limited amount of soil displacement usually less than fifty cubic yards. Excavation activity typically involving a single backhoe digging a small trench. Example: Test Pit Installations.
- (3) Drilling: borings typically penetrate approximately 30 feet of vadose zone into the groundwater. Hollow-system augering has been proposed as the primary drilling method. The emission factor for drilling has been assigned a constant as presented in Appendix 2 - Estimation of Emission Rates.
- (4) Vehicular Traffic on Unpaved Roadways: the volume of traffic associated with a particular RFI/RI activity will vary according to the type of excavation performed. Heavy vehicular traffic flow is assumed to be associated with major excavations. Light vehicular flow is associated with minor excavations primarily due to equipment needs and support team involvement. A sensitivity analysis of the vehicular traffic model is presented in Appendix 2, Estimation of Emission Rates.

Other activities have been proposed in RI workplans; however, based upon preliminary computations, the scenarios identified will result in the highest emissions. Appendix 2 provides a detailed analysis of the emission rate calculations for each of the scenarios. The references for each of the modeling algorithms have been provided as well as the actual formula used.

2.1.1.2 Step by Step Process Explanation

The establishment of soil thresholds was based on the following basic steps:

- 1) Identify the principal contaminants (Appendix 1)
- 2) Calculate activity-specific emission rates (Appendix 2)
- 3) Disperse the contaminant to the site boundary (Appendix 3)
- 4) Calculate the relative intake and resulting risk (Appendix 4)
- 5) Establish soil threshold levels based on acceptable risk (Appendix 5)

Step 1

Principal contaminants are identified based on site-specific data. Most OUs have some borehole data which has been screened using the analyte list in the RFI/RI workplans. Additional discussion regarding this development is discussed in Appendix 1. A comparison of the site data with the known information pertaining to slope factors for potential carcinogens and reference doses for noncarcinogens is then performed.

Step 2

The calculation of activity-specific (e.g., drilling, excavations, etc.) emission rates was then derived using EPA fugitive dust emission rates for various construction activities. Several conservative assumptions were applied in this step. For example, each excavation activity was assumed to occur all day (10 hour work day) for 365 days/year. Several other key assumptions are also listed in Appendix 2.

Step 3

The dispersion of the contaminant to the RFP property site boundary was conducted using Gaussian Plume Dispersion modeling (Turner 1967). Appendix 3 provides a complete discussion of the input parameters. The prevailing wind direction as indicated on the 1990 daytime wind rose was towards the southeast approximately 40 percent of the time. This input was utilized as the percent leeward fraction. Dispersion calculations were performed for each emission activity within each modeling zone (A,B,C and OU3). All volatile organic compounds were assumed to be completely volatilized.

Step 4

Contaminant intake and the resulting potential risk due to the off-site airborne transport of hazardous and/or dangerous materials from the RFP were calculated. Several conservative assumptions are recommended by the EPA for calculating intake of hazardous substances. The basic formulas used to calculate intake were taken from the EPA Risk Assessment Guidance for Superfund Sites (EPA 1989). The formulas utilized give breathing rates and standard man body weight constants. These factors were used in the spreadsheet tables presented in Appendix 3. Additional receptor parameters used to calculate contaminant intakes are presented in Table A.4-1 of Appendix 4. Potential carcinogenic and noncarcinogenic factors were input into the spreadsheets with the appropriate unit conversions. The acceptable upper bound lifetime cancer risk for known or suspected carcinogens is 1×10^{-4} to 1×10^{-6} lifetime excess cancer risk (40 CFR 300). The 10^{-6} risk level is used as the "point of departure" for multiple contaminants at a site or multiple pathways of exposure. In addition, assumptions that would err on the side of safety were consistently applied. Appendix 4, Risk Calculations, contains additional discussion regarding the treatment of parameter uncertainty.

Step 5

Soil threshold levels were calculated by setting the acceptable risk value to a dosimetric/risk performance objective (see Appendix 5). An assumed soil concentration was input into the spreadsheet and resulted in a derived risk to a receptor downwind. The performance objective was defined by setting the risk level to 1×10^{-6} or the hazard index to 0.1. A soil threshold or concentration was then back-calculated by starting from the target (the performance objective) and calculating the source that would lead to this target. An example of such a back-calculation is provided in Appendix 5. The hazard index is defined as the estimated daily intake divided by the reference dose for a noncarcinogen assuming a lifetime daily intake. Attachment 1 to Appendix 5 lists soil threshold levels for each contaminant of concern in each modeling zone for each emission activity. This table will serve as the primary guidance table for evaluating the Stage I and Stage II mitigative measure and associated monitoring requirements.

2.1.2 Preventive Measures Assessment

The main objective of this section is to identify contaminant dispersion control technologies and processes associated with DOE and Superfund facilities and discuss the major attributes relative to RFI/RI activity described in previous sections. This section of the PPCD is an abstract of Appendix 6, Dispersion Prevention Techniques. The techniques developed are based upon the feasibility section of the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988).

The primary reference used for identifying dust control measures was the Dust Control Handbook (EPA, 1985). A two step process consistent with RI/FS guidance was used to evaluate the control measures relevant to RFP RFI/RI activities. Step one identified suitable technologies. Step two ranked the control measures which are

technically feasible and implementable to achieve the lowest achievable emission rate. The ranking system was based primarily on effectiveness and implementability consistent with guidance. Cost was given a lesser consideration.

Selecting dust prevention control methods involved considering specific measures to prevent the spread of contaminants while conducting RFI/RI activities. A section entitled General Control Measures was added to specify what steps will be taken on a routine basis in order to ensure the absolute minimal spread of soil contamination. (Refer to Section A.6.2 in Appendix 6).

The potential exists that site-specific soil contaminants could be transported from one location to another as a result of moving equipment from activity stations. In order to prevent such transport of contaminants, decontamination procedures have been developed. They include: SOP 1.3 General Equipment Decontamination, and 1.4 Heavy Equipment Decontamination. Additional procedures that will minimize the potential for transportation of site-specific contaminants from one activity area to another are identified in Attachment One of the IPPCD (See Appendix 8). Included are procedures for handling of decontamination and wash waters, handling of drilling fluids and cuttings, and handling of residual samples.

The evaluation criteria involved a ranking of the control measure implementability and efficiency. Specific control measure efficiency ratings were based on fugitive dust suppression. The specific relevance to RFP environmental conditions was considered in evaluating the implementability of each technique.

Appendix 6 also provides a brief discussion of the dust producing activities considered under the evaluation. Dust control measures were identified for each emission activity.

2.1.2.1 Major Excavations

For the major excavations, the following dust suppression techniques were evaluated: area spray with water, area spray with a water-surfactant mixture, chemical dust suppressant, foam, spray curtain, windscreen, and containment structures.

Area spraying with water had a 62-70 percent efficiency for five particulates and was determined to be "easily implemented." For these reasons, this method was determined to have the highest ranking. The discussion of the other alternatives can be found in Appendix 6.

2.1.2.2 Minor Excavations

The same control methodologies were evaluated for minor excavations producing the same recommendation, area spraying with water. This ranking was based on the method being "very effective" and "easily implemented."

2.1.2.3 Drilling

Drilling activities for test wells or monitoring wells can involve the use of various drilling techniques, including those discussed in Section 2.2.1.1 of this document. Dust suppression needs are expected to be minimal and can be handled with portable spray units.

2.1.2.4 Unpaved Roads

Numerous types of surfactants are available for road application; however, the introduction of additional chemicals to a Superfund site could present additional waste disposal requirements. Spraying with water was specified with recommended

applications of 0.125 gallons/square yard every 20 minutes (EPA 1985). However, the utilization of chemical dust suppressants is recommended when dust produced by heavy traffic cannot be controlled by watering.

2.1.3 Monitoring Requirements

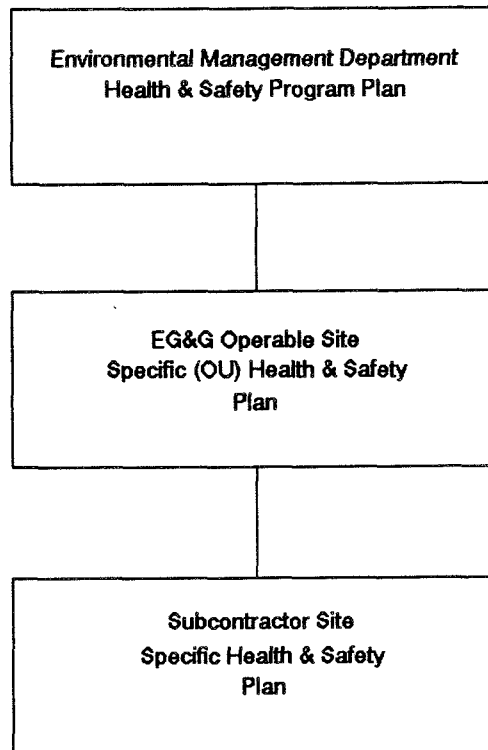
Appendix 7, Air Monitoring Requirements, contains a description of the instrumentation and methodology used for evaluating the airborne concentrations of hazardous and radioactive contaminants. This section summarizes the key elements of the Stage 1 and Stage 2 monitoring program. The program covers occupational monitoring requirements as well as site boundary perimeter air monitoring practices.

2.1.3.1 RFI/RI Monitoring Program

The PPCD is broken into two stages (1 and 2), each stage has similar monitoring needs based on differing soil contaminant concentration levels.

The administrative responsibilities fall primarily on the project manager in charge of field operations. There are several levels of an umbrella type of H&S workplan documentation. Figure 2 depicts the hierarchy of H&S plans. An increase in detail regarding monitoring requirements is inherent throughout the documents. The RFP site-wide H&S Program serves as the basis for developing site-specific H&S plans. Guidance documents are provided by EG&G to subcontractors in the form of a RFP Health and Safety Program Plan (EG&G 1990a) and the RFP Health and Safety Plan Workbook (EG&G 1990b). Both of these documents have been reviewed by EPA and CDH and the responses to resulting comments have been submitted to both agencies. In addition to this guidance, EG&G has a Site-Specific H&S Plan under which the remediation subcontractor develops their own H&S Plan,

FIGURE 2
HEALTH & SAFETY PLAN HIERARCHY



which in turn must be approved by the RFP Safety and Hygiene Department. Specific program responsibilities will be described in Section 2.4 of this report.

2.1.3.1.1 Stage 1 Monitoring

Stage 1 monitoring occurs when the average soil contaminant concentrations are less than the soil threshold levels listed in Appendix 5, Attachment A.5.1. The primary elements of the Stage 1 monitoring program include:

- Wind speed
- Soil moisture measurements
- Total suspended particulate measurements
- Others as specified by the site-specific H&S Plan.

As a minimum requirement for any RFI/RI intrusive activity, wind speed and soil moisture tests are evaluated prior to startup (EG&G Site-wide H&S Workplan). TSP sampling will be conducted under the recommendation of the site H&S Officer and/or the project manager. HNU and OVA meters and other occupational health equipment may be used as recommended by the site H&S Coordinator. On-site documentation requirements include the completion of the PPCD monitoring checklist as provided in Appendix 7.

2.1.3.1.2 Stage 2 Monitoring

Stage 2 monitoring consists of all elements required under Stage 1 but with greater emphasis on frequency and occupational limitations. Upwind and downwind TSP measurements can be verified by high volume air sampling to demonstrate the effectiveness of the selected mitigative measure. Worker breathing zone sampling may also occur to increase surveillance of worker exposure.

2.1.3.1.3 Work Start/Stop Criteria

As discussed in Appendix 7, public site boundary and worker start/stop criteria have been established. The stop work order will be given when the real-time instrumentation depicts a reading below the established soil moisture, or above wind speed, or TSP contaminant alarm levels which are based on RFP ALARA or H&S Action levels. The conditions for restart of activities are outlined in Section A.7.6 of Appendix 7.

2.1.3.2 Nonradioactive Ambient Air Monitoring

The nonradioactive ambient air monitoring program utilizes high-volume air samplers located at the east entrance to RFP. This program has been developed to demonstrate compliance with the Clean Air Act Amendments of 1970 and 1977, as defined by the National Ambient Air Quality Standards (NAAQS) and Colorado Air Quality Control Commission Ambient Air Standards. The EPA Respirable Particulate Standards (issued July 1, 1987) address respirable particles, referred to as Particulate Matter-10 or PM-10, particles less than or equal to 10 μm . PM-10 samples are operated every sixth day in accordance with the EPA reference high-volume air sampling method issued October 6 and December 1, 1987, (EG&G 1989).

2.1.3.3 Radioactive Ambient Air Monitoring

The RFP radioactive ambient air monitoring program consists of 23 on-site air samplers and 14 perimeter samplers bordering the facility. There are also 14 community samplers located throughout the metro area. The samplers operate continuously at a volumetric flowrate of approximately 12 liters per second collecting air particulates on fiberglass filters (99.97 percent efficient for relevant particle sizes).

Filters are collected biweekly, composited by location, and analyzed monthly for plutonium. (EG&G 1989).

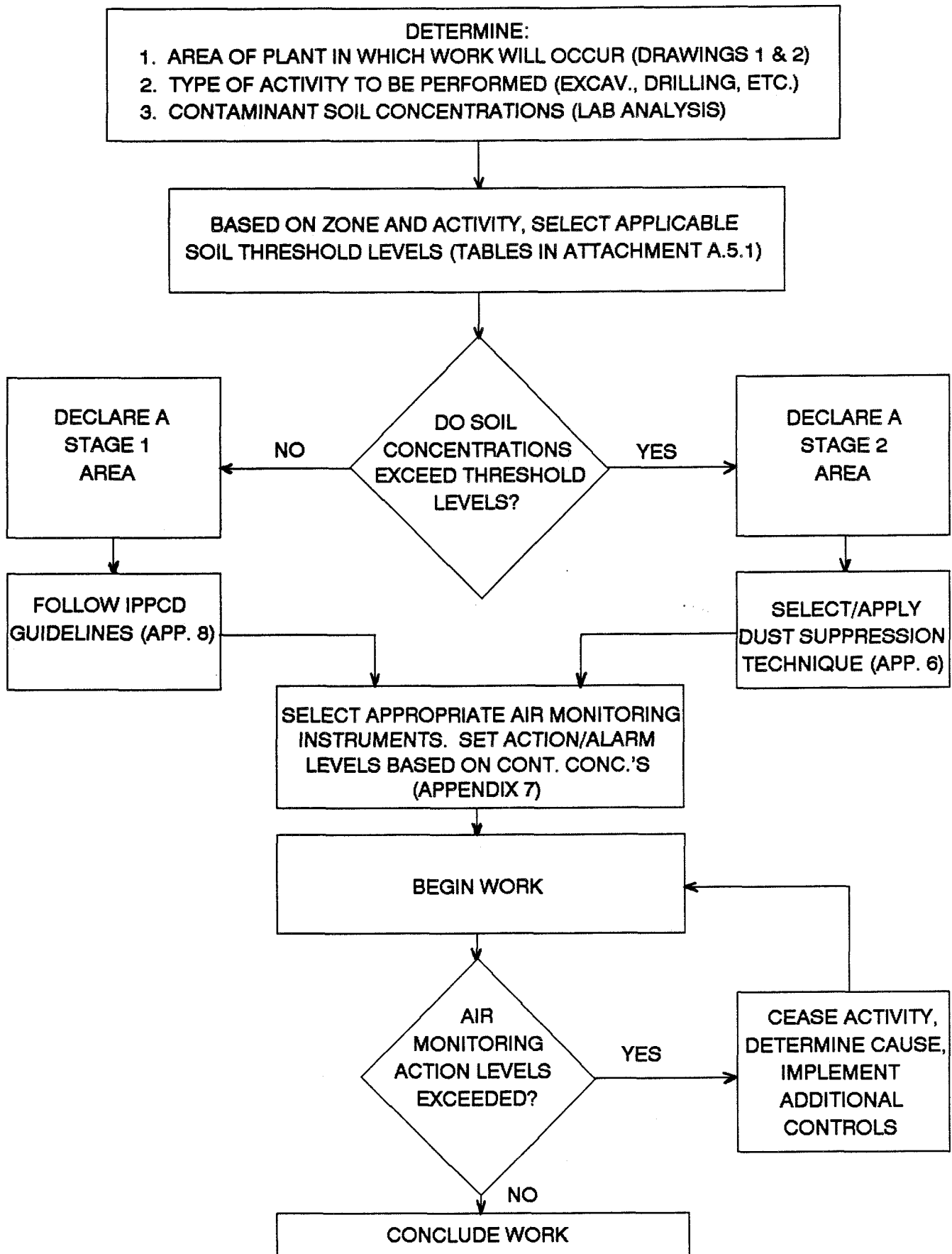
The nonradioactive and radioactive ambient air monitoring programs will provide additional verification of the implementation and effectiveness of the PPCD. Results from these programs will be correlated to on-site occupational monitoring data. RFI/RI fugitive dust emissions are expected to be undetectable at the site boundary considering "real-time" or instantaneous readout ability of state-of-the-art instrumentation. The ambient air programs currently utilize laboratory analysis which requires lengthy turnaround times. The PPCD monitoring plan will focus on real-time instrumentation and contaminant-specific detection limitations.

2.1.4 Implementation Plan

This section will describe how the PPCD will be implemented including guidance from existing SOPs and the IPPCD. This implementation plan has been developed to lay out the step by step process necessary to fulfill the purpose of the PPCD.

A simplified flow chart of the major steps required to implement the PPCD is given in Figure 3. The following steps will utilize the soil contaminant threshold limits derived in previous sections. The soil threshold table listed as Attachment A.5-1 in Appendix 5, is the primary reference on which to base the Stage 1 and Stage 2 decisions.

FIGURE 3
DECISION MAKING FLOW CHART



2.1.4.1 PPCD Step by Step Breakdown

Step 1

The PM conducts a pre-startup activity review meeting to evaluate the potential for particulate emissions potentially containing hazardous substances associated with planned activities. Other key individuals such as the Activity Field Supervisor and the subcontractor H&S representatives are present to provide input. The Radiological/H&S Work Permit (RFP Health and Safety Procedure 6.05) and an Excavation Permit (RFP HSP 6.01) are completed at this time. Appendix 8, Interim Plan for Prevention of Contaminant Dispersion (IPPCD) lists the relevant SOPs which will also be discussed during the pre-startup meeting.

The RFI/RI workplan is also reviewed to verify inclusion of the following startup prerequisites:

- Equipment is available to evaluate the wind speed. The latter must be below 15 mph or 35 mph, depending on the type of earth moving or other dust generating operations. Wind speed shut down criteria definition and responsible individuals will be identified within documents located in the project files.
- Equipment is available to evaluate soil moisture which must be above 15 percent (or the extent practicable) prior to startup of intrusive activities.
- Monitoring equipment capable of detecting the TSP Occupation Trigger Level and off-site public shutdown criteria shall be available with supporting operational procedures and qualified operators. Additional instrumentation may include: Piezobalances, Minirams,

Laser Particle Counters, HNU, OVA and various portable radiation detection equipment and H&S equipment as deemed necessary by the Site H&S Coordinator.

If some of these prerequisites cannot be met, work will not begin until the work plan is amended (with justifications) and approved.

Step 2

The PM should consider the extent and applicability of the site characterization data. A preliminary data collection activity may be indicated if site characterization data are not adequate to make a reasonable hazard evaluation. Available site-specific (OU, IHSS, etc.) soil analytical data are reviewed. An OU may contain multiple IHSS, and the extent of site characterization data may be variable in terms of completeness and quality. This step involves comparing site-specific soil contaminant concentrations to those presented in the soil threshold summary tables (Appendix 5, Attachment A.5-1). The RFI/RI activities (drilling, excavation, etc.) are selected from the table and correlated to the known contaminants. The most stringent soil threshold is then selected and used for the comparison.

The decision is then made as to whether the activity will require Stage 1 or Stage 2 monitoring (see Appendix 7). If the activity is determined to be Stage 2, additional assessment will be required to select the appropriate contaminant dispersion control techniques and monitoring requirements. Each emission activity will be reviewed to select the appropriate preventive measure. Appendix 6 Table A.6-3 has summarized the most appropriate technique with rankings. The preventive measure is selected and implemented under the supervision of the PM. The PM will then inspect the operation and make adjustments as deemed necessary.

Step 3

Stage 1 or Stage 2 monitoring requirements are identified based on the evaluation in Step 2. The site-specific H&S coordinator and the subcontractor H&S liaison meet and review the PPCD monitoring plan. Other SOPs may be referenced as they are developed; however, the objective of the monitoring program must be fulfilled with supporting documentation located in either EG&G's or the subcontractor's project files. The basic monitoring and reporting requirements should be reviewed to verify adequate understanding and delineation of responsibilities prior to startup.

Shutdown criteria are established based on the occupational action levels for hazardous materials and Local Air Monitoring Trigger Levels for occupational principal contaminants in soils and on off-site risk based exposure criterion. Local Air Monitoring Trigger Levels for occupational principal contaminants are developed in each individual site-specific Health and Safety Plan. Pu²³⁹ is used in this case as an example. The IPPCD (see Appendix 8) states that local monitoring of Total Suspended Particulate (TSP) at individual activity worksites shall be conducted using a TSI "Piezobalance" Model 3500 Aerosol Mass Monitor real-time instrument (or equivalent). The trigger level concentrations were established (Pu²³⁹ DAC/10) to provide protection for workers potentially exposed to plutonium contaminated soil. The Derived Air Concentration levels (DOE Order 5480.11) for plutonium will typically be the most restrictive occupational exposure level at RFP.

Step 4

Once the RFI/RI activity has begun operations, the monitoring data are assessed to determine the adequacy of the mitigative measure. Stage 1 operations will include using water spray applications, verifying soil moisture content, monitoring wind speeds, and incorporating general control measures such as limiting vehicle

speeds. The real-time monitoring data will verify the effectiveness of dust suppression techniques.

If the TSP results indicate dust loading concentrations above the occupational action levels, intrusive activities will be stopped and reevaluated in terms of precautionary and dispersion resumption requirements to protect workers. Similarly, intrusive activities will be stopped if the most restrictive principal contaminant shutdown criterion for the off-site public is exceeded. In this event, the reevaluation will consider the need to apply a more effective dispersion preventive measure. The steps identified in the IPPCD, Section IV, Additional Worker Health and Safety Monitoring Requirements by the SSH & SP, will be followed prior to the startup of activities. The project files are then updated with the real-time monitoring data.

2.2 Example PPCD Demonstration - 881 Hillside Monitoring Well Installation

This section provides an example of how the PPCD will work using actual site data. OU1 - 881 Hillside has been selected with monitoring well installation as the potential emission activity.

2.2.1 Rocky Flats Plant Area Location

The 881 Hillside monitoring well installations and their support activities will occur primarily in Zone B at the RFP. This zone has a dispersion distance of 2.9 km based on the conservative assumption that the center of activity for this zone falls on its boundary intersecting the vector leading to the nearest off-site receptor. This vector represents the average wind speed in the most common wind direction at RFP (Appendix 3 attachments).

2.2.2 Scenario Identification

Monitoring well installation at the 881 Hillside location will, in general, involve the following activities:

- Hollow-stem auguring by a drill rig. Typical well dimensions are assumed to be 0.2 m (8 in.) diameter by 9 m (30 ft) deep.
- Traffic over unpaved roads, assumed to be 10 vehicle kilometers per 10 hour work period.

In predicting emission rates associated with the above activities, it is assumed that the duration of the activity (installation of 1 well) will be 10 hours. This assumption enables the emission factors for the activities, in units of kg of soil emitted/well drilled and kg of soil emitted/vehicle kilometer traveled (VKT), to be translated to a rate having units of mass/time.

2.2.3 Emission Rate Estimation

The following models were used to predict particulate emission factors for the aforementioned activities (Tistinic, 1984).

Well Drilling

Emission Factor = 0.25 kg/well

Vehicle Traffic

$$\text{Emission (kg/VKT)} = K (1.7) (s/12) (S/48) (W/2.7)^{0.7} (w/4)^{0.5} (365-p)/365$$

K	=	aerodynamic particle size multiplier (0.45)
s	=	silt content of road surface material (%)
S	=	mean vehicle speed (km/hr)
W	=	mean vehicle weight (Mg)
w	=	mean number of wheels
p	=	number of days with at least 0.254 mm of precipitation per year.

These models were obtained from a memorandum through the CDH, Air Pollution Control Division prepared by Mr. Tom Tistinic, a public health engineer. The memorandum addresses fugitive particulate emissions through a compilation of emission factors recommended for use in estimating emissions from mining activities. The content of the memorandum was derived primarily from the EPA's Compilation of Air Pollutant Emission Factors (AP-42). Recent discussions with the Colorado Department of Health have confirmed the agency's preference for using the models presented in the memorandum.

Appendix 2 of this report provides a detailed discussion on the applicability of the models to the activities expected to occur at the RFP.

2.2.4 Identification of Principal Contaminants (OU Specific Data)

The initial screening for principal contaminants at RFP is discussed in Appendix 1. Specific soil action level concentrations were determined for the principal contaminants (PCs) included in Table 2.3.1. The table is divided into radionuclides, non-radionuclides (solids), and volatile organic compounds (VOCs) and semi-VOCs. Slope factors and reference doses (RfDs) are also shown where applicable. Note that additional discussion including slope factors and RfDs is in Appendix 4.

Table 2.3.1
Phase II Listing of RFP Potential Contaminants
with Established Slope Factors and Reference Concentrations

Principal Contaminants (PCs)	L.E.C.R. Slope Factors (PCD) $\wedge -1$	HI Inh. RfC (mg/kg/day)
<u>Radionuclides</u>		
Uranium 233 & 234	2.70E-08	
Uranium 235	2.50E-08	
Uranium 238	2.40E-08	
Americium 241	4.00E-08	
Plutonium 239 & 240	4.10E-08	
Tritium	7.80E-14	
Strontium 89	2.90E-12	
Strontium 90	5.60E-11	
Cesium 137	4.90E-11	
Radium 226	3.00E-09	
Radium 228	6.50E-10	
<u>Non-Radionuclides</u>	(mg/kg/day) $\wedge -1$	(mg/kg/day)
Arsenic	5.00E+01	
Barium		1.00E-03
Beryllium	8.40E+00	
Cadmium	6.10E+00	
Chromium III		5.70E-06
Chromium VI	4.10E+00	5.70E-06
Manganese		1.14E-04
Mercury		8.60E-05
Hexachlorocyclohexane (alpha)	6.30E+00	
Hexachlorocyclohexane (beta)	1.80E+00	
Heptachlor	4.50E+00	
Heptachlor Epoxide	9.10E+00	
Aldrin	1.70E+01	
Dieldrin	1.60E+00	
DDT	3.40E-01	
Chlordane (alpha, gamma)	1.30E+00	
Toxaphene	1.10E+00	
<u>VOCs & Semi-VOCs</u>		
Chloroform	8.10E-02	
1,1,1-Trichloroethane		3.00E+00
Carbon Tetrachloride	1.30E-01	
Benzene	3.00E-02	
Toluene		6.00E-01
Dichloromethane	2.00E-03	9.00E-01
Xylenes		9.00E-02
MEK		9.00E-01
1,2-Dichloroethane	9.10E-02	
Bromomethane		2.00E-02
Carbon Disulfide		3.00E-03
1,1-Dichloroethene	1.20E+00	
1,1-Dichloroethane		1.00E+00
Vinyl Acetate		6.00E-02
1,3-Dichloropropene	1.30E-01	6.00E-03
1,1,2-Trichloroethane	5.70E-02	
Bromoform	3.90E-03	
Tetrachloroethene	1.80E-03	
Chlorobenzene		5.00E-02
Ethylbenzene		3.00E-01
Styrene	2.00E-03	
Vinyl Chloride	2.90E-02	
1,2-Dichloroethane	9.10E-02	
1,2-Dichloropropane	1.30E-01	
1,1,2,2-Tetrachloroethane	2.00E-01	
2-Chloroethyl Ether	1.10E+00	
1,4-Dichlorobenzene		2.00E-01
1,2-Dichlorobenzene		4.00E-01
Nitrobenzene		6.00E-03
Hexachloroethane	1.40E-02	
1,2,4-Trichlorobenzene		3.00E-02
Hexachlorobutadiene	7.80E-02	
Hexachlorocyclopentadiene		2.00E-04
2,4,6-Trichlorophenol	1.10E-02	
Hexachlorobenzene	1.60E+00	

2.2.5 Soil Threshold Selection Process

The 881 Hillside contaminants were identified using site-specific characterization data. The resulting compilation (Step III as shown in Figure 2) is a site-specific identification of the principal contaminants for the purpose of implementing the PPCD. The Phase III list is based on the positive identification of contaminants and their corresponding concentrations from OU-specific sampling and analysis efforts. The aforementioned selection process is detailed further in Appendix 1.

A "List III" compilation of the PCs for the 881 Hillside Area is presented in Table 2.3.2. The PCs are listed with their highest observed and their average soil concentrations.

2.2.6 Soil Data Comparison with Threshold Levels

Table 2.3.3 compares existing concentrations of PCs along with the calculated threshold levels for well installation and support vehicle traffic in the 881 Hillside Area. The action levels come from the spreadsheets for these activities (see Attachment A.3.4). This comparison demonstrates that none of the PCs exceed threshold levels. Therefore, this activity is considered to be under Stage 1 monitoring requirements.

TABLE 2.3.2

**SOIL PRINCIPAL CONTAMINANTS
OUI - 881 HILLSIDE AREA**

<u>Contaminant</u>	<u>Observed Highest Concentration</u>	<u>Average Concentration</u>
Dichloromethane	0.590 µg/g	0.047 µg/g
2-Butanone (MEK)	0.390 µg/g	0.099 µg/g
1,1,1- Trichloroethane	0.110 µg/g	0.030 µg/g
Tetrachloroethene	0.190 µg/g	0.071 µg/g
1,2-Dichloroethane	0.010 µg/g	0.009 µg/g
Bromomethane	0.006 µg/g	0.006 µg/g
Toluene	0.025 µg/g	0.015 µg/g
Arsenic	24 µg/g	8.7 µg/g
Barium	810 µg/g	120 µg/g
Beryllium	1.9 µg/g	0.9 µg/g
Cadmium	6.6 µg/g	3.0 µg/g
Chromium (total)	28 µg/g	12 µg/g
Manganese	563 µg/g	191 µg/g
Mercury	2.07 µg/g	0.30 µg/g
Uranium 233, 234	1.7 pCi/g	0.96 pCi/g
Uranium 238	1.9 pCi/g	0.89 pCi/g
Strontium 89,90	1.9 pCi/g	0.25 pCi/g
Plutonium 239, 240	0.91 pCi/g	0.04 pCi/g
Americium 241	0.15 pCi/g	0.02 pCi/g
Cesium 137	2.6 pCi/g	0.27 pCi/g
Tritium	0.73 pCi/g	0.16 pCi/g
Radium 226	No data	No data
Radium 228	No data	No data
Uranium 235	No data	No data

TABLE 2.3.3 COMPARISON OF MEASURED SOIL CONCENTRATIONS TO THRESHOLD LEVELS

Contaminant	Observed Highest Concentration	Average Concentration	Soil Threshold Levels Well Drilling	Soil Threshold Levels Vehicle Traffic
Dichloromethane	0.590 µg/g	0.047 µg/g	1,470,000 µg/g	N/A
2-Butanone (MEK)	0.390 µg/g	0.099 µg/g	19,000,000 µg/g	N/A
1,1,1-Trichloroethane	0.110 µg/g	0.030 µg/g	63,200,000 µg/g	N/A
Tetrachloroethene	0.190 µg/g	0.071 µg/g	1,640,000 µg/g	N/A
1,2-Dichloroethane	0.010 µg/g	0.009 µg/g	32,400 µg/g	N/A
Bromomethane	0.006 µg/g	0.006 µg/g	421,000 µg/g	N/A
Toluene	0.025 µg/g	0.015 µg/g	12,600,000 µg/g	N/A
Arsenic	24 µg/g	8.7 µg/g	100,000 µg/g	2,670 µg/g
Barium	810 µg/g	120 µg/g	35,700,000 µg/g	952,000 µg/g
Beryllium	1.9 µg/g	0.9 µg/g	595,000 µg/g	15,900 µg/g
Cadmium	6.6 µg/g	3.0 µg/g	819,000 µg/g	21,800 µg/g
Chromium (total)	28 µg/g	12 µg/g	204,000 µg/g	5,430 µg/g
Manganese	563 µg/g	191 µg/g	4,070,000 µg/g	109,000 µg/g
Mercury	2.07 µg/g	0.30 µg/g	3,070,000 µg/g	81,900 µg/g
Uranium 233, 234	1.7 pCi/g	0.96 pCi/g	104,000 pCi/g	2,760 pCi/g
Uranium 238	1.9 pCi/g	0.89 pCi/g	116,000 pCi/g	3,110 pCi/g
Strontium 89,90	1.9 pCi/g	0.25 pCi/g	49,900,000 pCi/g	1,330,000 pCi/g
Plutonium 239, 240	0.91 pCi/g	0.04 pCi/g	68,200 pCi/g	1,820 pCi/g
Americium 241	0.15 pCi/g	0.02 pCi/g	69,900 pCi/g	1,860 pCi/g
Cesium 137	2.6 pCi/g	0.27 pCi/g	57,000,000 pCi/g	1,520,000 pCi/g
Tritium	0.73 pCi/g	0.16 pCi/g	35,800,000,000 pCi/g	955,000,000 pCi/g
Radium 226	No data	No data	932,000 pCi/g	24,800 pCi/g
Radium 228	No data	No data	4,300,000 pCi/g	115,000 pCi/g
Uranium 235	No data	No data	112,000 pCi/g	2,980 pCi/g

2.2.7 Mitigation Measure Identification

As shown in Table 2.3.3, known concentrations for each of the PCs do not exceed the action levels. Therefore, Stage 1 mitigation measures are sufficient for both well drilling and vehicle traffic. Stage 1 mitigative measures include wind speed measurements, soil moisture testing, total suspended particulate real time measurements, and unpaved road wetting applications.

2.2.8 Monitoring Program Initiation

Monitoring requirements for the well installation activities of the 881 Hillside Area are discussed in Appendix 7. These activities will require Stage 1 monitoring which includes implementing air monitoring procedures in the vicinity of the work area to provide assurance that off-site releases are kept within the limits imposed by the risk analysis (Appendix 4). Both real-time and cumulative (integrating) concentrations of contaminants in air will be measured. Appropriate air sampling and monitoring instruments will be selected depending on the types of contaminants that are present or suspected to be present at the site.

The IPPCD (Appendix 8) describes monitoring requirements and specifies occupational action levels. The IPPCD has been reviewed by EPA/CDH and will act as the SOP until other procedures are developed.

2.2.9 Documentation Requirements

The Project Manager will ensure that requirements of the air sampling and monitoring plan are followed at the work site. The implementation of Air Monitoring Requirements will be structured in a manner similar to the action checklist included in Attachment A.7-1 to Appendix 7. This checklist includes but is not limited to:

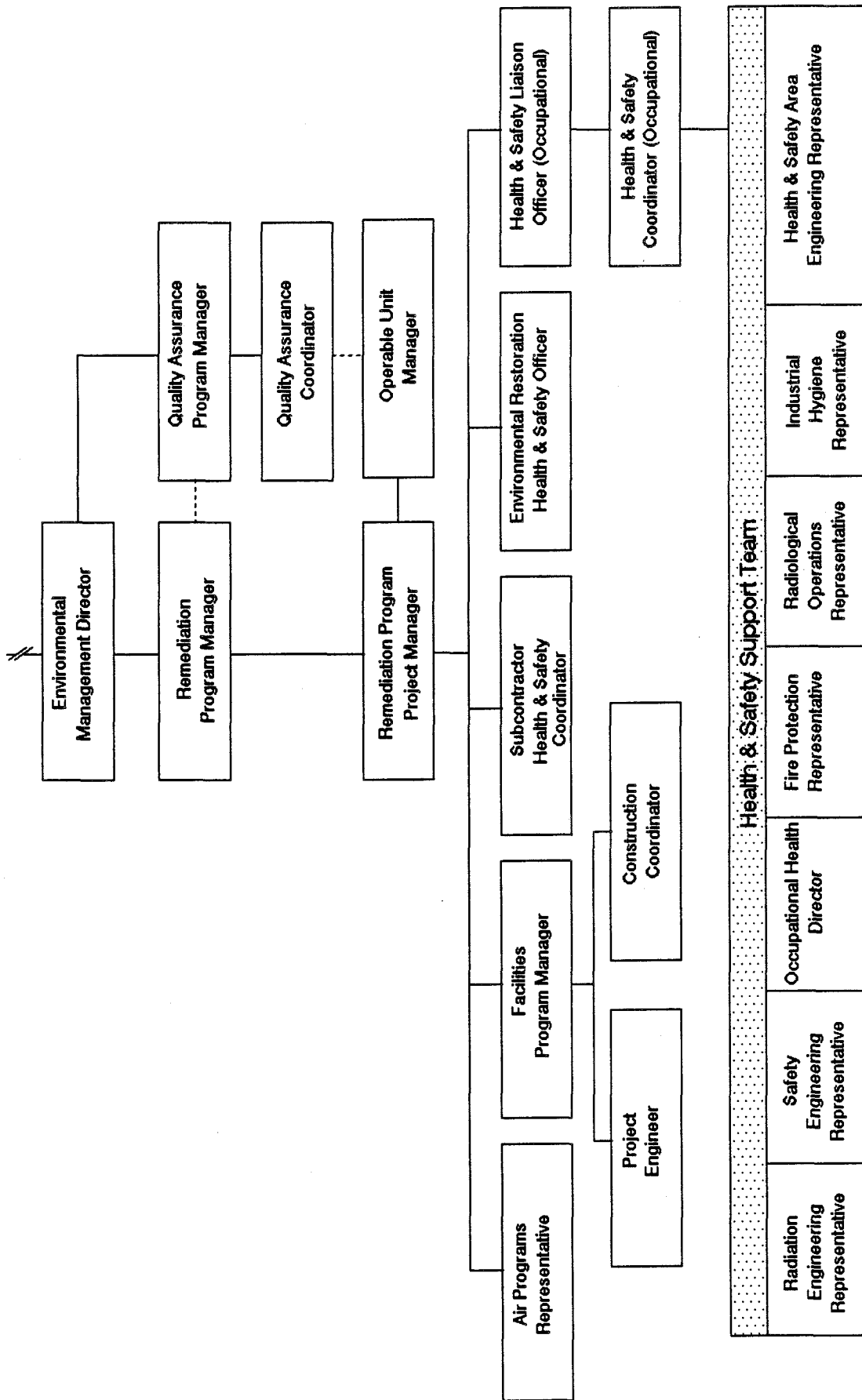
- Identification of potential dust generating activities;
- Determination of contaminant concentrations in the soil;
- Determination of Stage 1 or 2 work area and control measures required.
- Selection of windspeed and soil moisture thresholds;
- Selection of monitoring and sampling equipment;
- Calculation of action levels; and
- Placement of monitoring and sampling equipment.

Adherence to the specific SOP for well installation will supplement worker protection measures in the Site-Specific Health and Safety Plan.

2.3 Administrative Procedure for the EG&G Project Manager

This section outlines the administrative procedures to be followed by the PM when conducting activities that are within the scope of the PPCD. An example organization chart is shown in Figure 4. It specifies the responsibilities and the authorities of key EG&G and contractor personnel involved in the supervision of activities and remedial action sites, and describes the process to be used to resolve issues which might arise during operations.

FIGURE 4
EXAMPLE ORGANIZATION CHART



2.3.1 Key Personnel Position Description/Organizational Chart

Environmental Management (EM) Department Director

The EM Department Director is responsible for overall department activities, including the establishment and execution of the QA Program and the assignment of an independent Quality Assurance Program Manager.

Remediation Program Manager

The Remediation Program (RP) Manager implements RP-related construction activities, QA project plans, and corrective actions, and provides overall direction and guidance to the PM.

Project Manager

The Project Manager is responsible for all project activities. Specific duties include: monitoring health and safety documents, communicating project requirements, and monitoring project progress and budget performance. The Project Manager also serves as the liaison to the Department of Energy - Rocky Flats Office, EPA, and the Colorado Department of Health.

Quality Assurance Program Manager, (QAPM)

The QAPM assures the development, implementation and execution of the QA program.

Operable Unit Manager

The Operable Unit Manager ensures that applicable Standard Operating Procedure and Standard Operating Procedure Addenda requirements are implemented during field operations.

Quality Assurance Coordinator (QAC)

The QAC coordinates QA Program activities, provides technical support in quality affecting activities, and maintains an inventory of division SOPs and quality assurance documents.

Air Programs Representative

The Air Programs Representative is assigned to the project by Environmental Monitoring and Assessment Division. The Air Programs group monitors meteorology and air quality of the Environmental Restoration Department. The Air Programs Representative is responsible for operation of high-volume air samplers and meteorological monitors.

Environmental Restoration Health and Safety Officer, (ERHSO)

The ERHSO assists the Project Manager in implementing the ER Health and Safety Program. Specific responsibilities include: implementation of the technical facets of the PPCD such as establishing monitoring criteria and evaluating thresholds; ensuring that a site-specific Health and Safety Plan is written for each Operable Unit; ensuring that subcontractors submit site or task-specific health and safety plans for approval; ensuring that a Site Health and Safety Officer is assigned to each Operable Unit; and ensuring that adequate safety support and review procedures are established so that site personnel are not at risk while working at the site.

2.3.2 Quality Assurance/Quality Control

A Quality Assurance Plan Addendum is prepared for each project and is supplemental to the Site-Wide QA Project Plan. The assigned Quality Assurance Officer approves the plan and produces the project quality report.

The QAO has the following additional responsibilities:

- Reviewing and tracking matters involving nonconformances and those requiring corrective action;
- Approving nonconformance and corrective action resolutions;
- Approving the Response Action Contractors QA plans and procedures;
- Supporting the RP Divisions Quality Coordinator as appropriate;
- Reporting issues involving matters adverse to quality to the ER Department Manager; and
- Issuing stop work in matters adverse to quality.

The QC officer has the following responsibilities:

- Incorporating quality, inspection, and records requirements into EG&G internal Phase 1B project related plans, procedures and instructions which affect quality;
- Performing surveillance activities of the work being performed;

- Recommending corrective action on matters requiring corrective action resolution;
- Ensuring the quality records of the project are forwarded to the records file;
- Reporting issues involving matters adverse to quality to the RP Division Manager;
- Compiling a final Phase 1B Project Quality report to be submitted to the RP Division Manager, the ER Department Director, the ER Department QAO, and the records file upon completion of the project; and
- Coordinating quality matters with the ER Department QAO.

2.3.3 Records Management

Records management personnel shall generate a records index which identifies the record type to be produced on the project, the unique identifier, the record retention time, and the location of the record within the record system. Records management personnel and/or EM Department supervision will classify records as to their retention status (i.e., lifetime/permanent records, nonpermanent records, and records with limited storage and retention requirements).

Documents and records that relate in any way to the presence of hazardous substances, pollutants, or contaminants at the RFP, or to the implementation of the IAG, shall be classified as lifetime records to be retained for the life of ER activities, and at a minimum will be preserved for 10 years after termination of the IAG. This includes all documents identified as being in the possession of the DOE or its

divisions, employees, agents, accountants, or contractors. After the minimum 10-year period, DOE shall notify the EPA and the State of Colorado at least 45 days prior to destruction or disposal of any such documents or records. EPA and the State of Colorado will make a determination if the documents should be retained for a longer period of time.

3.0 REFERENCES

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APPENDIX 1

PRINCIPAL CONTAMINANTS

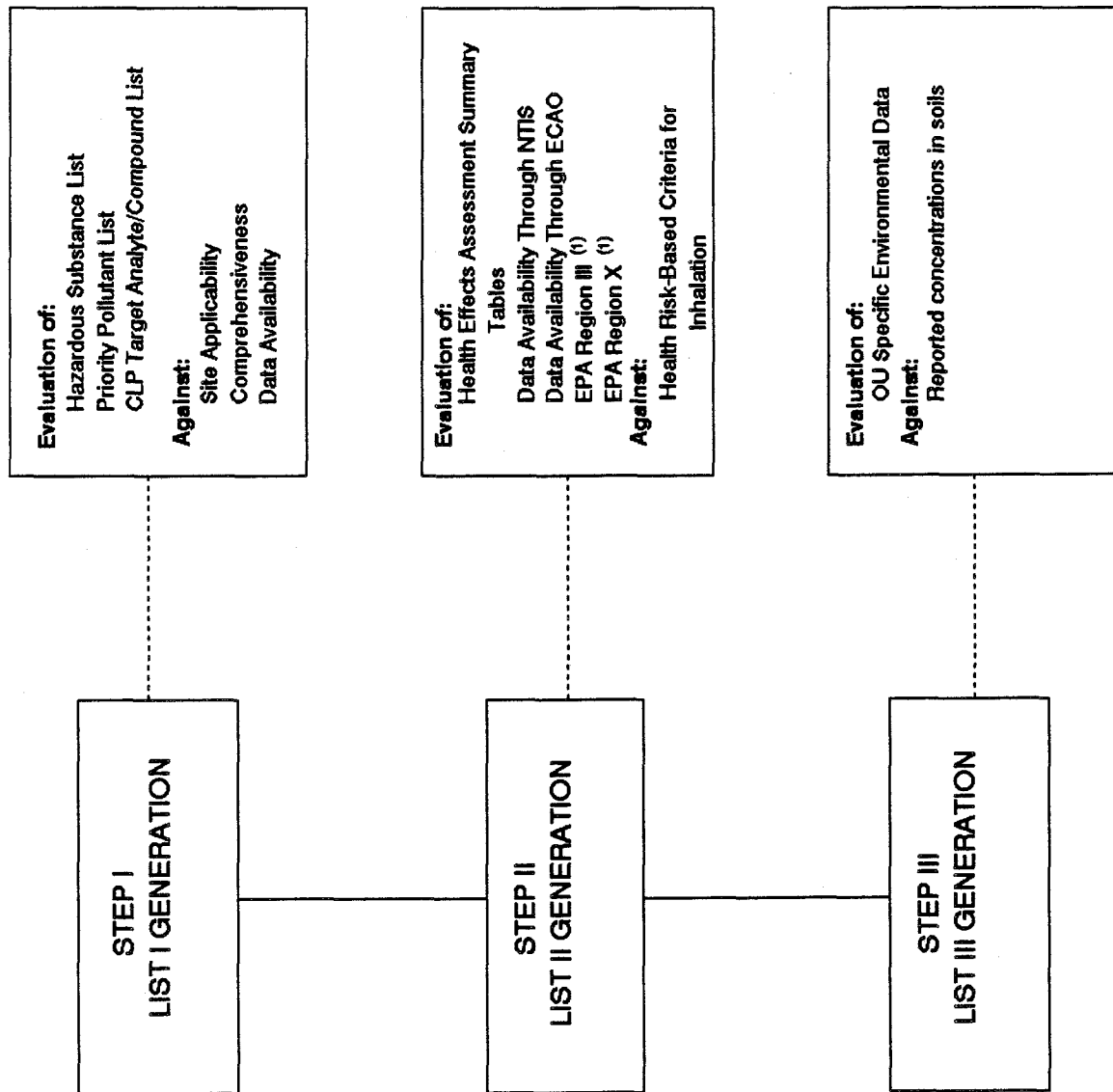
A.1.1 INTRODUCTION

The principal contaminants listed in the Plan for Prevention of Contaminant Dispersion (PPCD) were identified during a three phase process. This process is illustrated in Figure A.1-1. The initial step developed an appropriate and comprehensive starting point (List I) for identifying principal contaminants. The second step screened the potential contaminants of List I against currently available health effects data. When appropriate health effects information existed for a potential contaminant (i.e., inhalation slope factors and/or reference concentrations), the constituent was carried on to a second list (List II). The third step will condense List II by evaluating those constituents against operable unit-specific characterization data. The resulting compilation (List III) will be a site-specific identification of the principal contaminants for the purpose of implementing the PPCD. The third step, conducted by the Operable Unit (OU) Manager, will be based on the positive identification of contaminants and their corresponding concentrations from OU-specific sampling and analysis efforts.

A.1.2 LIST I SELECTION

The current Rocky Flats analyte list presented in Appendix B of the Draft Rocky Flats Site-Wide Quality Assurance Project Plan for CERCLA RI/FS and RCRA RFI/CMS Activities, (EG&G, 1991) was selected as the starting point for identifying the principal contaminants because it is the most comprehensive and representative list of potential environmental contaminants for the RFP. The Appendix B list was based on results of investigations conducted for the Comprehensive Environmental Assessment and Response Program (CEARP; presently the DOE Environmental Restoration Program) and from ongoing negotiations among the DOE, EPA, and the State of Colorado. The CEARP Phase I activities (1985-1986) included researching past waste management practices,

FIGURE A.1-1
DEVELOPMENT OF PRINCIPAL CONTAMINANTS



(1) For comparison purposes only

reviewing disposal records, and interviewing Rocky Flats personnel. These activities provided documentation for the DOE CERCLA program and for these EPA CERCLA preremedial activities: (1) Federal Facility Site Discovery and Identification Findings, (2) Preliminary Assessment, (3) Site Inspection, and (4) Hazard Ranking System evaluation. The findings were published in CEARP Phase I, Installation Assessment of Rocky Flats Plant, (DOE, 1986). This investigation resulted in a list of potentially contaminated sites and their suspected contaminants. These sites and corresponding suspected contaminants are the Solid Waste Management Units and Individual Hazardous Substance Sites scheduled for investigation under the Interagency Agreement (IAG).

Other chemical listings, such as the EPA Hazardous Substances List, EPA Priority Pollutants list, and EPA's Contract Laboratory Program Target Analyte/Compound List, were eliminated because they lacked the comprehensiveness of the Appendix B listing. Although these lists are routinely selected for use in characterization efforts, they do not address all the potential principal contaminants at the RFP. Chemical listings such as RCRA Appendix IX and the ChemRisk Task 1 Report (ChemRisk, 1991) were eliminated because they lacked the specificity to environmental contamination at the Rocky Flats Plant.

The final consideration for List I selection was data availability since it is a key factor in successfully implementing the PPCD. The Appendix B list represents the constituents that are currently analyzed for in environmental samples collected at the RFP. As a result, informed decisions can be made and implemented based on existing environmental characterization data for specific OUs. The Appendix B list (List I) is presented in Attachment A.1.1.

A.1.3 LIST II SELECTION

List I constituents were evaluated against health risk assessment and regulatory data presented in the Integrated Risk Information System (IRIS) and the EPA Health Effects Assessment Summary Tables (HEAST). IRIS is updated monthly and presents the most current information available to the public from the U.S. Department of Health and Human Services (USDHHS). Information on IRIS supersedes all other sources because the database contains only those reference concentrations (RfCs) and unit risk factors (slope factors) that have been verified by the RfC or CRAVE Workgroups. The data from IRIS is also compiled annually and presented in the HEAST. The health effects data evaluated for the PPCD were RfCs for toxicity from subchronic and chronic inhalation exposure and unit risk values for carcinogenicity based on lifetime inhalation exposure. The List II chemicals selected during the second phase of evaluation were those for which health risk information was verifiable in final drafts of Health Effects Assessment documents (HEAs), Health and Environmental Effects Profiles (HEEPs), Health and Environmental Effects Documents (HEEDs), Health Assessment Documents (HADs), and Air Quality Criteria Documents (AQCDs).¹

Because the purpose of the PPCD is to provide a consistent mechanism for assessing the potential for airborne transport of site-specific environmental contaminants caused by IAG related activities (e.g. remedial actions) and to present options for controlling such dispersion, the receiving medium has been limited to air and the exposure pathway has been limited to inhalation. This approach was agreed upon through negotiations among the DOE, EPA, and the State of Colorado.

¹Constituents from List I that did not have published RfCs or unit risk values in the IRIS database or the HEAST are undergoing further screening. A request for toxicological profiles developed by the Agency for Toxic Substances and Disease Registry (ATSDR) through the National Technical Information Service (NTIS) was made in an attempt to obtain information on the toxicological effects of these constituents. Additionally, EPA's Environmental Criteria and Assessment Office (ECAO) has also been contacted as a potential source of information. Therefore, only qualitative statements can be made.

Therefore, the List II constituent selection process focused on the inhalation exposure pathway and identifying only those constituents for which accepted inhalation RfCs and unit risk factors were available. List II, Potential Principal Contaminants, is presented in Attachment A.1.2 along with the pertinent health risk data.

A.1.3.1 REFERENCE CONCENTRATIONS (RfCs)

As stated in the HEAST, EPA, 1991, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population that is likely to be without an appreciable risk of deleterious effects during a portion of the lifetime, in the case of a subchronic RfC, or during the lifetime, in the case of a chronic RfC. Subchronic inhalation RfCs were used for the List II constituent listing based on applicability to the modeling scenario selected for determining risk associated with potential contaminant dispersion. Uncertainty factors are factored into the RfC and reflect scientific judgement regarding the various types of data used to estimate RfC values (EPA, 1991). Uncertainty factors can be found in the cited references for List II development.

Generally, the contributing elements to the uncertainty factor include (1) variations in human sensitivity when extrapolating from valid human studies involving subchronic or long-term exposure of average healthy subjects, (2) extrapolations from long-term animal studies to the case of humans, and (3) expansion from subchronic to chronic RfCs. Additionally, a modifying factor may be applied to account for professional assessment of uncertainties of the study and database not explicitly addressed by uncertainty factors. A subchronic RfC is usually derived, for chemicals in which a chronic RfC has been determined. RfC values are also specific for the route of exposure (EPA, 1991).

The RfC is used as a reference point for gauging the potential effects of other exposures. Usually, exposures that are less than the RfC are not likely to be

associated with health risks; however, a clear distinction that would categorize all exposures below the RfC as risk-free and all exposures in excess of the RfC as causing adverse effects cannot be made. In addition, RfC values, and particularly those with limitations in the quality or quantity of supporting data, are subject to change as additional information becomes available (EPA, 1991).

A.1.3.2 UNIT RISK FACTORS (SLOPE FACTORS)

Quantitative carcinogenic risk assessments are performed for chemicals in Groups A and B and on a case-by-case basis for chemicals in Group C, as defined below:

- Group A - Human Carcinogen (sufficient evidence of carcinogenicity in humans)
- Group B - Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
- Group C - Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)

Quantitative carcinogenic estimates are specific for the route of exposure. In some instances, values for inhalation may have been extrapolated from oral exposure values by EPA.

A.1.4 LIST III GENERATION

It is the OU Manager's responsibility to conduct the third phase identification of OU-specific principal contaminants by utilizing existing characterization data. This phase of the screening process compares the constituents on List II against existing characterization data to identify positively detected contaminants that are then carried over to List III. List III is an OU-specific compilation of contaminants and will be utilized for the design and implementation of a plan for the prevention of dispersion of those contaminants. In the event that insufficient data exists for a specific OU, it may be necessary to carry all List II constituents to List III.

A.1.4.1 EXAMPLE LIST III GENERATION - OU 1, 881 HILLSIDE AREA

Existing characterization data from borehole samples collected at OU1, 881 Hillside Area, were screened against the potential principal contaminants identified on List II. List III for the 881 Hillside Area is presented in Table A.1-1. The contaminants and their highest observed concentrations (disregarding sample depth) and average concentrations are presented for use in the design and implementation stages of the PPCD. Non-radionuclides are expressed in $\mu\text{g/g}$ (ppm) and radionuclides are expressed in pCi/g.

A.1.5 REFERENCES

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TABLE A.1-1
PRINCIPAL CONTAMINANTS
OU1 - 881 HILLSIDE AREA

<u>Contaminant</u>	<u>Observed Highest Concentration</u>	<u>Arithmetic Mean Concentration</u>
Dichloromethane	0.590 $\mu\text{g/g}$	0.047 $\mu\text{g/g}$
2-Butanone	0.390 $\mu\text{g/g}$	0.099 $\mu\text{g/g}$
1,1,1-Trichloroethane	0.110 $\mu\text{g/g}$	0.030 $\mu\text{g/g}$
Tetrachloroethene	0.190 $\mu\text{g/g}$	0.071 $\mu\text{g/g}$
1,2-Dichloroethane	0.010 $\mu\text{g/g}$	0.009 $\mu\text{g/g}$
Bromomethane	0.006 $\mu\text{g/g}$	0.006 $\mu\text{g/g}$
Toluene	0.025 $\mu\text{g/g}$	0.015 $\mu\text{g/g}$
Arsenic	24 $\mu\text{g/g}$	8.7 $\mu\text{g/g}$
Barium	810 $\mu\text{g/g}$	120 $\mu\text{g/g}$
Beryllium	1.9 $\mu\text{g/g}$	0.9 $\mu\text{g/g}$
Cadmium	6.6 $\mu\text{g/g}$	3.0 $\mu\text{g/g}$
Chromium (total)	28 $\mu\text{g/g}$	12 $\mu\text{g/g}$
Manganese	563 $\mu\text{g/g}$	191 $\mu\text{g/g}$
Mercury	2.07 $\mu\text{g/g}$	0.30 $\mu\text{g/g}$
Uranium 233, 234	1.7 pCi/g	0.96 pCi/g
Uranium 238	1.9 pCi/g	0.89 pCi/g
Strontium 89,90	1.9 pCi/g	0.25 pCi/g
Plutonium 239, 240	0.91 pCi/g	0.04 pCi/g
Americium 241	0.15 pCi/g	0.02 pCi/g
Cesium 137	2.6 pCi/g	0.27 pCi/g
Tritium	0.73 pCi/g	0.16 pCi/g
Radium 226	No data	No data
Radium 228	No data	No data
Uranium 235	No data	No data

Attachment A.1.1

**Appendix B, Draft Rocky Flats Site-Wide
Quality Assurance Project Plan
for CERCLA RI/FS and RCRA RFI/CMS Activities
Environmental Restoration Program
March, 1991**

ENVIRONMENTAL RESTORATION
Site-Wide QA Project Plan

DRAFT

Manual: QAPjP
Section No. APP B Rev 0, Draft A
Page: 1 of 12
Effective Date: Proposed, 03/01/91

TITLE: APPENDIX B

Approved By:

 2/17/91
Director, Environmental Restoration

APPENDIX B

Table B1: Analytical Methods, Detection Limits, and
Data Quality Objectives

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SU	GH	SOIL	SED	Required Detection Limits		Precision Objective	Accuracy Objective
						Water	Soil/Sed.		
INDICATORS									
Total Suspended Solids	EPA 160.2 ^a	X ^u				10 mg/L	NA	20%RPD ^c	80-120% LCS Recovery
Total Dissolved Solids	EPA 160.1 ^a	X ⁱ	X ⁱ			5 mg/L	NA	20%RPD ^c	80-120% LCS Recovery
pH	EPA 150.1 ^a	X ^u	X ⁱ			0.1 pH units	0.1 pH units	NA	±0.05 pH units
INORGANICS									
Target Analyte List - Metals									
Aluminum	EPA CLP SOL ^a			X		200 ug/L ^c	40 mg/Kg ^c	**	***
Antimony	EPA CLP SOL ^a					60	12		
Arsenic (GFAA)	EPA CLP SOL ^a					10	2		
Barium	EPA CLP SOL ^a					200	40		
Beryllium	EPA CLP SOL ^a					5	1.0		
Cadmium	EPA CLP SOL ^a					5	1.0		
Calcium	EPA CLP SOL ^a					5000	2000		
Chromium	EPA CLP SOL ^a					10	2.0		
Cobalt	EPA CLP SOL ^a					50	10		
Copper	EPA CLP SOL ^a					25	5.0		
Cyanide	EPA 335.3 (modified for CLP) ^{a,c}					5	10		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits		Precision Objective	Accuracy Objective
						Water	Soil/Sed.		
Target Analyte List - Metals (continued)									
Iron	EPA CLP SOW					100 ug/L*	20 mg/Kg*	**	***
Lead (GFAA)	EPA CLP SOW					3	1.0		
Magnesium	EPA CLP SOW					5000	2000		
Manganese	EPA CLP SOW					15	3.0		
Mercury (CVAA)	EPA CLP SOW					0.2	0.2		
Nickel	EPA CLP SOW					40	8.0		
Potassium	EPA CLP SOW					5000	2000		
Selenium (GFAA)	EPA CLP SOW					5	1.0		
Silver	EPA CLP SOW					10	2.0		
Sodium	EPA CLP SOW					5000	2000		
Thallium (GFAA)	EPA CLP SOW					10	2.0		
Vanadium	EPA CLP SOW					50	10		
Zinc	EPA CLP SOW					20	4.0		
Other Metals		X*	X*	X	X			WATER/SOIL	WATER/SOIL
Molybdenum	EPA CLP SOW (ICAP)					8 ug/L*	40 mg/Kg*	**	***
Cesium	EPA CLP SOW					1000	200		
Strontium	EPA CLP SOW					200	40		
Lithium	EPA CLP SOW					100	20		
Tin	EPA CLP SOW					200	40		
Other Inorganics									
Percent Solids	EPA 160.3*			X	X	NA	10 mg	NA	NA
Sulfide	EPA 376.1*			X	X	NA	4 ug/g	Same as metals	Same as metals

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SV	GV	SOIL	SED	Required Detection Limits Water	Soil/Sed.	Precision Objective	Accuracy Objective
ANIONS									
Carbonate	EPA 310.1 ^a	X ^b	X ^b			10 mg/L	NA	Same as metals	Same as metals
Bicarbonate	EPA 310.1 ^a	X ^b	X ^b			10 mg/L	NA		
Chloride	EPA 325.2 ^a	X ^b	X ^b			5 mg/L	NA		
Sulfate	EPA 375.4 ^a	X ^b	X ^b			5 mg/L	NA		
Nitrate as N	EPA 353.2 ^a or 353.3 ^a	X ^b	X ^b			1 mg/L	NA		
Fluoride	EPA 340.2 ^a	X ^b	X ^b			5 mg/L	NA		
Oil and Grease	EPA 413.2 ^a	X ^b				5 mg/L	NA	**	***
*Total Petroleum Hydrocarbons	EPA 418.1 ^a			X	X	NA	10 mg/kg	NA/40	NA/80-120
Target Compound List - Volatiles	EPA CLP 504 ^c	X ^b	X ^b	X	X			WATER/SOIL	WATER/SOIL
Chloromethane	EPA CLP 504 ^c					10 ug/L	10 ug/Kg (low) ^d	**	***
Bromomethane	EPA CLP 504 ^c					10	10		
Vinyl Chloride	EPA CLP 504 ^c					10	10		
Chloroethane	EPA CLP 504 ^c					10	10		
Methylene Chloride	EPA CLP 504 ^c					5	5		
Acetone	EPA CLP 504 ^c					10	10		
Carbon Disulfide	EPA CLP 504 ^c					5	5		
1,1-Dichloroethene	EPA CLP 504 ^c					5	5		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SU	GU	SOIL	SED	Required Detection Limits Water	Soil/Sed.	Precision Objective	Accuracy Objective
Target Compound List - Volatiles (continued)		X ^a	X ^a	X	X			WATER/SOIL	WATER/SOIL
1,1-Dichloroethane	EPA CLP SO ₄ ^c					5 ug/L	5 ug/Kg(LOW) ³	**	***
total 1,2-Dichloroethene	EPA CLP SO ₄ ^c					5	5		
Chloroform	EPA CLP SO ₄ ^c					5	5		
1,2-Dichloroethane	EPA CLP SO ₄ ^c					1	5		
2-Butanone	EPA CLP SO ₄ ^c					10	10		
1,1,1-Trichloroethane	EPA CLP SO ₄ ^c					5	5		
Carbon Tetrachloride	EPA CLP SO ₄ ^c					5	5		
Vinyl Acetate	EPA CLP SO ₄ ^c					10	10		
Bromodichloromethane	EPA CLP SO ₄ ^c					5	5		
1,2-Dichloropropane	EPA CLP SO ₄ ^c					5	5		
cis-1,3-Dichloropropene	EPA CLP SO ₄ ^c					5	5		
Trichloroethene	EPA CLP SO ₄ ^c					5	5		
Dibromochloromethane	EPA CLP SO ₄ ^c					5	5		
1,1,2-Trichloroethane	EPA CLP SO ₄ ^c					5	5		
Benzene	EPA CLP SO ₄ ^c					5	5		
trans-1,2-Dichloropropene	EPA CLP SO ₄ ^c					5	5		
Bromoform	EPA CLP SO ₄ ^c					5	5		
4-Methyl-2-pentanone	EPA CLP SO ₄ ^c					10	10		
2-Hexanone	EPA CLP SO ₄ ^c					10	10		
Tetrachloroethene	EPA CLP SO ₄ ^c					5	5		
Toluene	EPA CLP SO ₄ ^c					5	5		
1,1,2,2-Tetrachloroethane	EPA CLP SO ₄ ^c					5	5		
Chlorobenzene	EPA CLP SO ₄ ^c					5	5		
Ethyl Benzene	EPA CLP SO ₄ ^c					5	5		
Styrene	EPA CLP SO ₄ ^c					5	5		
Total Xylenes	EPA CLP SO ₄ ^c					5	5		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SU	GU	SOIL	SED	Required Detection Limits		Precision Objective	Accuracy Objective
						Water	Soil/Sed.		
Target Compound List - Semi-Volatiles			X ^a	X	X			WATER/SOIL	WATER/SOIL
Phenol	EPA CLP SO ₄ ^c					10 ug/L	330 ug/Kg ^b	**	***
bis(2-Chloroethyl)ether	EPA CLP SO ₄ ^c					10	330		
2-Chlorophenol	EPA CLP SO ₄ ^c					10	330		
1,3-Dichlorobenzene	EPA CLP SO ₄ ^c					10	330		
1,4-Dichlorobenzene	EPA CLP SO ₄ ^c					10	330		
Benzyl Alcohol	EPA CLP SO ₄ ^c					10	330		
1,2-Dichlorobenzene	EPA CLP SO ₄ ^c					10	330		
2-Methylphenol	EPA CLP SO ₄ ^c					10	330		
bis(2-Chloroisopropyl)ether	EPA CLP SO ₄ ^c					10	330		
4-Methylphenol	EPA CLP SO ₄ ^c					10	330		
N-Nitroso-Dipropylamine	EPA CLP SO ₄ ^c					10	330		
Hexachloroethane	EPA CLP SO ₄ ^c					10	330		
Nitrobenzene	EPA CLP SO ₄ ^c					10	330		
Isophorone	EPA CLP SO ₄ ^c					10	330		
2-Nitrophenol	EPA CLP SO ₄ ^c					10	330		
2,4-Dimethylphenol	EPA CLP SO ₄ ^c					10	330		
Benzoic Acid	EPA CLP SO ₄ ^c					50	1600		
bis(2-Chloroethoxy)methane	EPA CLP SO ₄ ^c					10	330		
2,4-Dichlorophenol	EPA CLP SO ₄ ^c					10	330		
1,2,4-Trichlorobenzene	EPA CLP SO ₄ ^c					10	330		
Naphthalene	EPA CLP SO ₄ ^c					10	330		
4-Chloroaniline	EPA CLP SO ₄ ^c					10	330		
Hexachlorobutadiene	EPA CLP SO ₄ ^c					10	330		
4-Chloro-3-methylphenol	EPA CLP SO ₄ ^c					10	330		
2-Methylnaphthalene	EPA CLP SO ₄ ^c					10	330		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GW	SOIL	SED	Required Detection Limits		Precision Objective	Accuracy Objective
						Water	Soil/Sed.		
Target Compound List - Semi-Volatiles (continued)			X ^a	X	X			WATER/SOIL	WATER/SOIL
Hexachlorocyclopentadiene	EPA CLP SO ₄ ^c					10 ug/L	330 ug/Kg ^d	**	***
2,4,6-Trichlorophenol	EPA CLP SO ₄ ^c					10	330		
2,4,5-Trichlorophenol	EPA CLP SO ₄ ^c					50	1600		
2-Chloronaphthalene	EPA CLP SO ₄ ^c					10	330		
2-Nitroaniline	EPA CLP SO ₄ ^c					50	1600		
Dimethylphthalate	EPA CLP SO ₄ ^c					10	330		
Acenaphthylene	EPA CLP SO ₄ ^c					10	330		
2,6-Dinitrotoluene	EPA CLP SO ₄ ^c					10	330		
3-Nitroaniline	EPA CLP SO ₄ ^c					50	1600		
Acenaphthene	EPA CLP SO ₄ ^c					10	330		
2,4-Dinitrophenol	EPA CLP SO ₄ ^c					50	1600		
4-Nitrophenol	EPA CLP SO ₄ ^c					50	1600		
Dibenzofuran	EPA CLP SO ₄ ^c					10	330		
2,4-Dinitrotoluene	EPA CLP SO ₄ ^c					10	330		
Diethylphthalate	EPA CLP SO ₄ ^c					10	330		
4-Chlorophenol Phenyl ether	EPA CLP SO ₄ ^c					10	330		
Fluorene	EPA CLP SO ₄ ^c					10	330		
4-Nitroaniline	EPA CLP SO ₄ ^c					50	1600		
4,6-Dinitro-2-methylphenol	EPA CLP SO ₄ ^c					50	1600		
N-nitrosodiphenylamine	EPA CLP SO ₄ ^c					10	330		
4-Bromophenyl Phenyl ether	EPA CLP SO ₄ ^c					10	330		
Hexachlorobenzene	EPA CLP SO ₄ ^c					10	330		
Pentachlorophenol	EPA CLP SO ₄ ^c					50	1600		
Phenanthrene	EPA CLP SO ₄ ^c					10	330		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SU	GW	SOIL	SED	Required Detection Limits		Precision Objective	Accuracy Objective
						Water	Soil/Sed.		
Target Compound List - Semi-Volatiles (continued)									
Anthracene	EPA CLP SOW					10 ug/L	330 ug/Kg ³	**	***
Di-n-butylphthalate	EPA CLP SOW					10	330		
Fluoranthene	EPA CLP SOW					10	330		
Pyrene	EPA CLP SOW					10	330		
Butyl Benzylphthalate	EPA CLP SOW					10	330		
3,3'-Dichlorobenzidine	EPA CLP SOW					20	660		
Benzo(a)anthracene	EPA CLP SOW					10	330		
Chrysene	EPA CLP SOW					10	330		
bis(2-ethylhexyl)phthalate	EPA CLP SOW					10	330		
Di-n-octyl Phthalate	EPA CLP SOW					10	330		
Benzo(b)fluoranthene	EPA CLP SOW					10	330		
Benzo(k)fluoranthene	EPA CLP SOW					10	330		
Benzo(a)pyrene	EPA CLP SOW					10	330		
Indeno(1,2,3-cd)pyrene	EPA CLP SOW					10	330		
Dibenz(a,h)anthracene	EPA CLP SOW					10	330		
Benzo(g,h,i)perylene	EPA CLP SOW					10	330		
Target Compound List - Pesticides/PCBs									
alpha-BHC	EPA CLP SOW		X ^o	X	X	0.05 ug/L	8.0 ug/Kg ³	**	***
beta-BHC	EPA CLP SOW					0.05	8.0		
delta-BHC	EPA CLP SOW					0.05	8.0		
gamma-BHC (Lindane)	EPA CLP SOW					0.05	8.0		
Heptachlor	EPA CLP SOW					0.05	8.0		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SW	GL	SOIL	SED	Required Detection Limits		Precision Objective	Accuracy Objective
						Water	Soil/Sed.		
Target Compound List - Pesticides/PCBs (continued)									
Aldrin	EPA CLP SOW		X ^a	X	X	0.05 ug/L	8.0 ug/Kg ^b	**	***
Heptachlor Epoxide	EPA CLP SOW					0.05	8.0		
Endosulfan I	EPA CLP SOW					0.05	8.0		
Dieldrin	EPA CLP SOW					0.10	16.0		
4,4'-DDE	EPA CLP SOW					0.10	16.0		
Endrin	EPA CLP SOW					0.10	16.0		
Endosulfan II	EPA CLP SOW					0.10	16.0		
4,4'-DDD	EPA CLP SOW					0.10	16.0		
Endosulfan Sulfate	EPA CLP SOW					0.10	16.0		
4,4'-DDT	EPA CLP SOW					0.10	16.0		
Methoxychlor	EPA CLP SOW					0.5	80.0		
Endrin Ketone	EPA CLP SOW					0.10	16.0		
alpha-Chlordane	EPA CLP SOW					0.5	80.0		
gamma-Chlordane	EPA CLP SOW					0.5	80.0		
Toxaphene	EPA CLP SOW					1.0	160.0		
AROCLOR-1016	EPA CLP SOW					0.5	80.0		
AROCLOR-1221	EPA CLP SOW					0.5	80.0		
AROCLOR-1232	EPA CLP SOW					0.5	80.0		
AROCLOR-1242	EPA CLP SOW					0.5	80.0		
AROCLOR-1248	EPA CLP SOW					0.5	80.0		
AROCLOR-1254	EPA CLP SOW					1.0	160.0		
AROCLOR-1260	EPA CLP SOW					1.0	160.0		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

Analyte	Method	SU	GU	SOIL	SED	Required Detection Limits		Precision Objective (Replicate Analyses)	Accuracy Objective (Laboratory Control Sample)
						Water	Soil/Sed.		
RADIONUCLIDES									
Gross Alpha	f, g, h, i, k, l, m, n	X ^u	X ⁱ	X	X	2 pCi/L	4 pCi/g	**	***
Gross Beta	f, g, h, i, k, l, m, n	X ^u	X ⁱ	X	X	4 pCi/L	10 pCi/g		
Uranium	f, h, i, m, n	X ^u	X ⁱ	X	X	0.6 pCi/L	0.3 pCi/g		
233+234									
Uranium 235, 238	f, h, i, m, n	X ^u	X ⁱ	X	X	0.6 pCi/L	0.3 pCi/g		
Americium 241	p, q	X ^u	X ⁱ	X	X	0.01 pCi/L	0.02 pCi/g		
Plutonium 239+240	o, p	X ^u	X ⁱ	X	X	0.01 pCi/L	0.03 pCi/g		
Tritium	f, g, h, m	X ^u	X ⁱ	X	X	400 pCi/L	400 pCi/L		
Strontium 89, 90	f, h, i, m	X ^u	X ⁱ	X	X	NA	1 pCi/g		
Strontium 90 only	f, h, i, m	X ^u	X ⁱ	X	X	1 pCi/L	NA		
Cesium 137	m	X ^u	X ⁱ	X	X	1 pCi/L	0.1 pCi/g		
Radium 226	f, g, h, m ¹	X ^u	X ⁱ			0.5 pCi/L	0.5 pCi/g		
Radium 228	f, g, h, m ¹	X ^u	X ⁱ			1 pCi/L	0.5 pCi/g		
FIELD PARAMETERS									
pH	1	X	X			± 0.1 pH unit	± 0.2 pH units		
Specific Conductance	1	X	X			2.5 umho/cm ¹	± 2.5% max. error at 500, 5000, 50000 umhos/cm plus probe;		
						25 umho/cm ²	± 3.0% max error at 250, 2500, and 25000 plus probe accuracy of ± 2.0%.		
						250 umho/cm ³	± 1.0°C		
Temperature	1	X	X			± 0.1°C			
Dissolved Oxygen	1	X				± 0.1 mg/L	± 10%		

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

- * For samples collected from IHSSs 102 and 105 only (BH01, BH02, BH03, BH04, BH05, BH06, BH07, BH08 (MU33), BH09, BH15, BH16, BH17, BH18, MU01, MU02, MU03, MU33 (BH08)).
- ** Precision objective = control limits specified in referenced method and/or Data Validation Guidelines.
- *** Accuracy objective = control limits specified in referenced method (in GRRASP for radionuclides).
- F = Filtered
U = Unfiltered
1. Measured in the field in accordance with instrument manufacturer's instructions. The instruments to be used are specified in Section 12.
 2. Medium soil/sediment required detection limits for pesticide/PCB TCL compounds are 15 times the individual low soil/sediment required detection limit.
 3. Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.
 4. Higher detection limits may only be used in the following circumstance: If the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the required detection limit. This is illustrated in the example below:

For lead:

Method in use - ICP
Instrument Detection Limit (IDL) - 40
Sample Concentration - 220
Required Detection Limit (IDL) - 3

The value of 220 may be reported even though the instrument detection limit is greater than the RDL.

Note: The specified detection limits are based on a pure water matrix. The detection limits for samples may be considerably higher depending on the sample matrix.

5. If gross alpha > 5 pCi/L, analyze for Radium 226; if Radium 226 > 3 pCi/L, analyze for Radium 228.
6. The detection limits presented were calculated using the formula in M.R.C. Regulatory Guide 4.14, Appendix Lower Limit of Detection, pg. 21, and follow:

$$LL' = \frac{4.66 \text{ (BKG/BKG DUR)}^{1/2}}{(2.22)(\text{Eff})(\text{CR})(\text{SR})(e^{-\lambda t})(\text{Aliq})} \quad \text{MDA} = \frac{4.66 \text{ (BKG/Sample DUR)}^{1/2}}{(2.22)(\text{Eff})(\text{CR})(\text{SR})(e^{-\lambda t})(\text{Aliq})}$$

Where:

LLD = Lower Limit of Detection in pCi per sample unit.
BKG = Instrument Background in counts per minute (CPM).
Eff = Counting efficiency in cpm/disintegration per minute (dpm).
CR = Fractional radiochemical yield.
SR = Fractional radiochemical yield of a known solution.
 λ = The radioactive decay constant for the particular radionuclide.
t = The elapsed time between sample collection and counting.
Aliq = Sample volume.
BKG DUR = Background count duration in minutes.

MDA = Minimum Detectable Activity in pCi per sample unit
BKG = same as for LLD
Eff = same as for LLD
CR = same as for LLD
SR = same as for LLD
 λ = same as for LLD
t = same as for LLD
Aliq = same as for LLD
Sample DUR = sample count duration in minutes

TABLE B1. ANALYTICAL METHODS, DETECTION LIMITS, AND DATA QUALITY OBJECTIVES

7. On 500 umho/cm range.
8. On 5000 umho/cm range.
9. On 50000 umho/cm range.
- a. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version).
- b. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, 7/88 (or latest version). The specific method to be utilized is at the laboratory's discretion provided it meets the specified detection limit.
- c. U.S. Environmental Protection Agency Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, 2/88 (or latest version).
- d. Methods are from "Methods for Chemical Analysis of Water and Wastes," U.S. Environmental Protection Agency, 1983, unless otherwise indicated.
- e. Methods are from "Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods," (SW-846, 3rd Ed.), U.S. Environmental Protection Agency.
- f. U.S. Environmental Protection Agency, 1979, Radiochemical Analytical Procedures for Analysis of Environmental Samples, Report No. EHS-LY-0539-1, Las Vegas, NV, U.S. Environmental Protection Agency.
- g. American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1985. Standard Methods for the Examination of Water and Wastewater, 16th ed., Washington, D.C., Am. Public Health Association.
- h. U.S. Environmental Protection Agency, 1976. Interim Radiochemical Methodology for Drinking Water, Report No. EPA-600/4-75-008. Cincinnati U.S. Environmental Protection Agency.
- i. Harley, J.H., ed., 1975, HASL Procedures Manual, HASL-300; Washington, D.C., U.S. Energy Research and Development Administration.
- j. US EPA-600/4-82-057.
- k. "Handbook of Analytical Procedures," USAEC, Grand Junction Lab. 1970, page 196.
- l. "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032, August 1980, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268.
- m. "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments," U.S.G.S. Book 5, Chapter A5, 1977.
- n. "Acid Dissolution Method for the Analysis of Plutonium in Soil," EPA-600/7-79-081, March 1979, U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, 1979.
- o. "Procedures for the Isolation of Alpha Spectrometrically Pure Plutonium, Uranium, and Americium," by E.H. Essington and B.J. Drennon, Los Alamos National Laboratory, a private communication.
- p. "Isolation of Americium from Urine Samples," Rocky Flats Plant, Health, Safety, and Environmental Laboratories.
- q. "Radioactivity in Drinking Water," EPA 570/9-81-002.
- r. If the sample or duplicate result is $< 5 \times \text{IDL}$, then the control limit is $\pm \text{IDL}$.

Attachment A.1.2

List II - Potential Principal Contaminants

PRINCIPAL CONTAMINANTS - METALS/INORGANICS

	Information Source	Inh RfC (s) (mg/kg/day)	Inh SF (mg/kg/day)-1
Arsenic	a,b	-----	0.5
Barium	a,b	0.001	-----
Beryllium	b	-----	8.4
Cadmium	b	-----	6.1
Chromium III	b	5.70E-06	-----
Chromium VI	b	5.70E-06	0.012
Manganese	a,b	1.14E-04	-----
Mercury	b	8.60E-05	-----

PRINCIPAL CONTAMINANTS - RADIONUCLIDES

	Information Source	Inhalation (pCi)-1
Uranium 233 + 234	b	2.70E-08
Uranium 235	b	2.50E-08
Uranium 238	b	2.40E-08
Americium 241	b	4.00E-08
Plutonium 239 + 240	b	4.10E-08
Tritium (gas)	b	7.80E-14
Strontium 89 + 90	b	2.90E-12
Strontium 90	b	5.60E-11
Cesium 137	b	5.00E-10
Radium 226	b	8.10E-08
Radium 228	b	1.80E-08

PRINCIPAL CONTAMINANTS - VOLATILE ORGANICS

	Information Source	Inh RfC (s) (mg/kg/day)	Inh SF (mg/kg/day)-1
Chloroform	a,b	-----	0.081
1,1,1-Trichloroethane	b	3	-----
Carbon Tetrachloride	b	-----	0.13
Benzene	a,b	-----	0.29
Toluene	a,b	0.6	-----
Dichloromethane (Methylene Chloride)	a,b	0.9	0.0002
Xylenes	a,b	0.09	-----
Methyl Ethyl Ketone (2-Butanone)	a,b	0.9	-----
1,2-Dichloroethane	a,b	-----	0.091
Bromomethane	a,b	0.2	-----
Carbon Disulfide	a,b	0.003	-----
1,1-Dichloroethene	a,b	-----	1.2
1,1-Dichloroethane	b	1	-----
Vinyl Acetate	a,b	0.06	-----
1,3-Dichloropropene	a,b	0.06	0.13
1,1,2-Trichloroethane	b	-----	0.057
Bromoform	a,b	-----	0.0039
Tetrachloroethene	b	-----	0.018
Chlorobenzene	a,b	0.05	-----
Ethylbenzene	a,b	0.3	-----
Styrene	a,b	-----	0.03
Vinyl Chloride	a,b	-----	0.029
1,2-Dichloroethane	a,b	-----	0.091
1,2-Dichloropropane	a,b	-----	0.13
1,1,2,2-Tetrachloroethane	a,b	-----	0.2

PRINCIPAL CONTAMINANTS - SEMIVOLATILE ORGANICS

	Information Source	Inh RfC (s) (mg/kg/day)	Inh SF (mg/kg/day)-1
bis(2-chloroethyl) ether	a,b	-----	1.1
1,4-Dichlorobenzene	a,b	0.7	-----
1,2-Dichlorobenzene	a,b	2	-----
Nitrobenzene	a,b	0.02	-----
Hexachloroethane	a,b	-----	0.014
1,2,4-Trichlorobenzene	b	0.03	-----
Hexachlorobutadiene	a,b	-----	0.078
Hexachlorocyclopentadiene	a,b	0.0007	-----
2,4,6-Trichlorophenol	a,b	-----	0.011
Hexachlorobenzene	a,b	-----	1.6

a - Integrated Risk Information System

b - Health Effects Assessment Summary Tables

PRINCIPAL CONTAMINANTS - PESTICIDES/PCBs

	Information Source	Inh RfC (s) (mg/kg/day)	Inh SF (mg/kg/day)-1
Hexachlorocyclohexane (alpha)	a,b	-----	6.3
Hexachlorocyclohexane (beta)	a,b	-----	1.8
Heptachlor	a,b	-----	4.5
Heptachlor Epoxide	a,b	-----	9.1
Aldrin	a,b	-----	17
Dieldrin	a,b	-----	1.6
DDT	a,b	-----	0.34
Chlordane (alpha, gamma)	a,b	-----	1.3
Toxaphene	a,b	-----	1.1

APPENDIX 2
ESTIMATION OF EMISSION RATES

A.2.1 INTRODUCTION

The developed activity scenarios were selected based on the expectation that their performance will contribute significantly to dust generation at the Rocky Flats Plant. The activities were assumed to be common to four defined areas (Zones A, B, and C, and Operable Unit 3) with the exception that the two excavation activities will not occur in Operable Unit 3. Preliminary calculations indicated that some RFI/RI intrusive activities such as trowel sampling and hand and small powered augers are insignificant emission sources. Presentation of this information to the working group resulted in the following activities:

- Drilling
- Light vehicle traffic
- Heavy vehicle traffic
- Minor excavation
- Major excavation

These activities were developed using known applications where possible. For instance, major excavation will involve the use of heavy equipment such as scrapers and front-shovel excavators. Therefore, in order to establish plausible receptor dose concentrations due to dust generation by operation of such equipment, their application to the construction of the 881 Hillside French Drain (considered a major excavation) was detailed. The following section provides descriptions and applicable dust emission models specific to the aforementioned activities.

A.2.2 ACTIVITY SCENARIO IDENTIFICATION

Drilling: Drilling involves the placement of wells at various locations throughout the site. These wells are assumed to be drilled to a depth of 30 ft. (9 m) with a diameter of 8 inches (0.2 m) in a period of 10 hours. The dust emission rate is estimated as 0.25 kg per well, based on typical well dimensions (Tistinic, 1984. This technical

memo has served as the CDH "dust manual" as referenced in the working group committee.) Volatile Organic Carbons (VOCs) are assumed to be distributed homogeneously through the well boring, and, conservatively, the VOCs in the displaced soil are assumed to be completely volatilized and emitted from the soil during the well drilling.

Light Vehicle Traffic: Light vehicle traffic is general activity support traffic (pickup trucks, security vehicles, etc.) traversing the site via unpaved roads. This classification of vehicle traffic assumes that the total traveled vehicle distance is in the range of 10 km in a 10 hour work period. The fugitive dust emission model used for this activity is:

$$\text{Emission (kg/VKT)} = K (1.7) (s/12) (S/48) (W/2.7)^{0.7} (w/4)^{0.5} (365-p)/365$$

VKT	=	Vehicle Kilometer Traveled
K	=	aerodynamic particle size multiplier (0.45)
s	=	silt content of road surface material (%)
S	=	mean vehicle speed (km/hr)
W	=	mean vehicle weight (Mg)
w	=	mean number of wheels
p	=	number of days with at least 0.254 mm of precipitation per year.

The values used for these variables in running this model were either assumed using good engineering judgement or obtained from various sources. The aerodynamic particle size multiplier, K, accompanied the model (Tistinic, 1984). The silt content, s, which is defined as that portion of the soil passing through a 200 mesh screen, was estimated to be 50 percent based on a soil survey for the area (Soil Conservation Service, 1980). The other variables were assumed to have the following values for purposes of completing the model:

<u>Variable</u>	<u>Assumed Value</u>
S	16 km/h (10 mph)
W	2.7 Mg (\approx 6000 lbs)
w	4
P	40

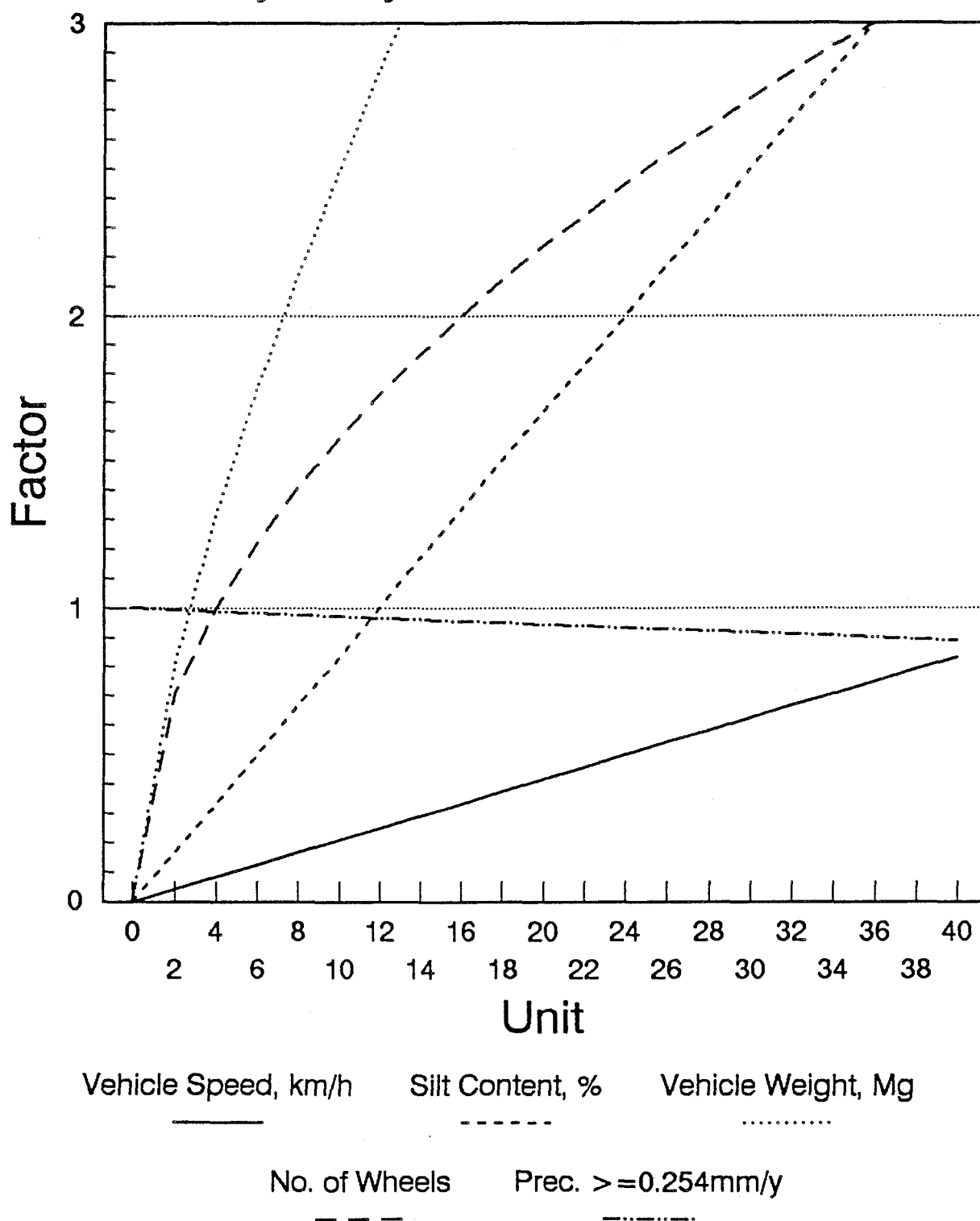
A simple sensitivity analysis (see Figure 1) performed on the variables of this model shows the effect of changes over the expected range of the variables. The slope of the line for a particular variable in a given unit range is an indication of the impact that changes in that variable have on the total emission factor (i.e., the greater the slope, the greater a given change in a particular variable will impact the total emission factor).

Figure 1 demonstrates that changes in mean vehicle weight have the greatest impact on emissions over the expected ranges of operation for all of the variables. Changes in the mean number of wheels on the vehicle and changes in silt content have impacts on the total emission rate that are similar to one another over their expected ranges of operation. The following list reflects the rank of the variables with regard to impact on dust emissions.

<u>RANK</u>	<u>VARIABLE</u>	<u>INCREASE RESULTS IN:</u>
1	W, Mean Vehicle Weight	Increase
2 (tie)	w, Mean No. of Wheels	Increase
	s, Silt Content	Increase
4	S, Vehicle Speed	Increase
5	P, Precipitation	Decrease

FIGURE 1

Sensitivity Analysis - Vehicle Traffic Model



It has been assumed that the soil being disturbed by vehicle traffic contains no VOCs; therefore, this activity does not contribute to potential VOC intake by off-site receptors.

Heavy Vehicle Traffic: Heavy vehicle traffic is identical to light vehicle traffic with the exception that this classification of vehicle traffic assumes that the total vehicle distance traveled is in the range of 100 km in a 10 hour work period.

Minor Excavation: Minor excavation refers to an excavation that requires a minimum amount of heavy equipment operation. The activity chosen to represent a minor excavation is the construction of a test pit with the dimensions of 7 ft. long x 5 ft. wide x 4 ft deep. Construction of a test pit will utilize a backhoe and be performed in a manner such that the top six inches of soil is removed and stored prior to excavating the balance of the pit. The top six inches of soil is assumed to contain radionuclides and will be isolated from the excavated soil. The predictive emission factor (batch drop model) for such an operation is:

$$\text{Emission (kg/Mg)} = K (0.0009) \frac{(s/5) (U/2.2) (H/1.5)}{(M/2)^2 (Y/4.6)^{0.33}}$$

K	=	aerodynamic particle size diameter (0.48)
s	=	silt content of material, %
U	=	mean wind speed, m/s
H	=	drop height, m
M	=	material moisture content, %
Y	=	dumping device capacity, m ³

As discussed in the section for light vehicle traffic, to run the above model variables were either assumed using good engineering judgement or obtained from various sources. K accompanied the emission model (Tistinic, 1984); s was estimated as 50 percent (Soil Conservation Service, 1980); the mean wind speed, U, was

estimated as 4.7 m/s from available wind rose data (see Appendix 3 - Dispersion Calculation); the material moisture content was estimated as 10 percent based on consultation with area experts; and the dumping device capacity was estimated as 0.25 m³ which is 1/3 the bucket capacity for a Caterpillar Model 416 (Caterpillar, 1989).

A simple sensitivity analysis (see Figure 2) performed on the variables of this model shows the effect of change over the expected range of the variables. Figure 2 demonstrates that changes in moisture content have the greatest impact by far on the total particulate emission factor. The following list reflects the rank of the variables with regard to impact on dust emissions.

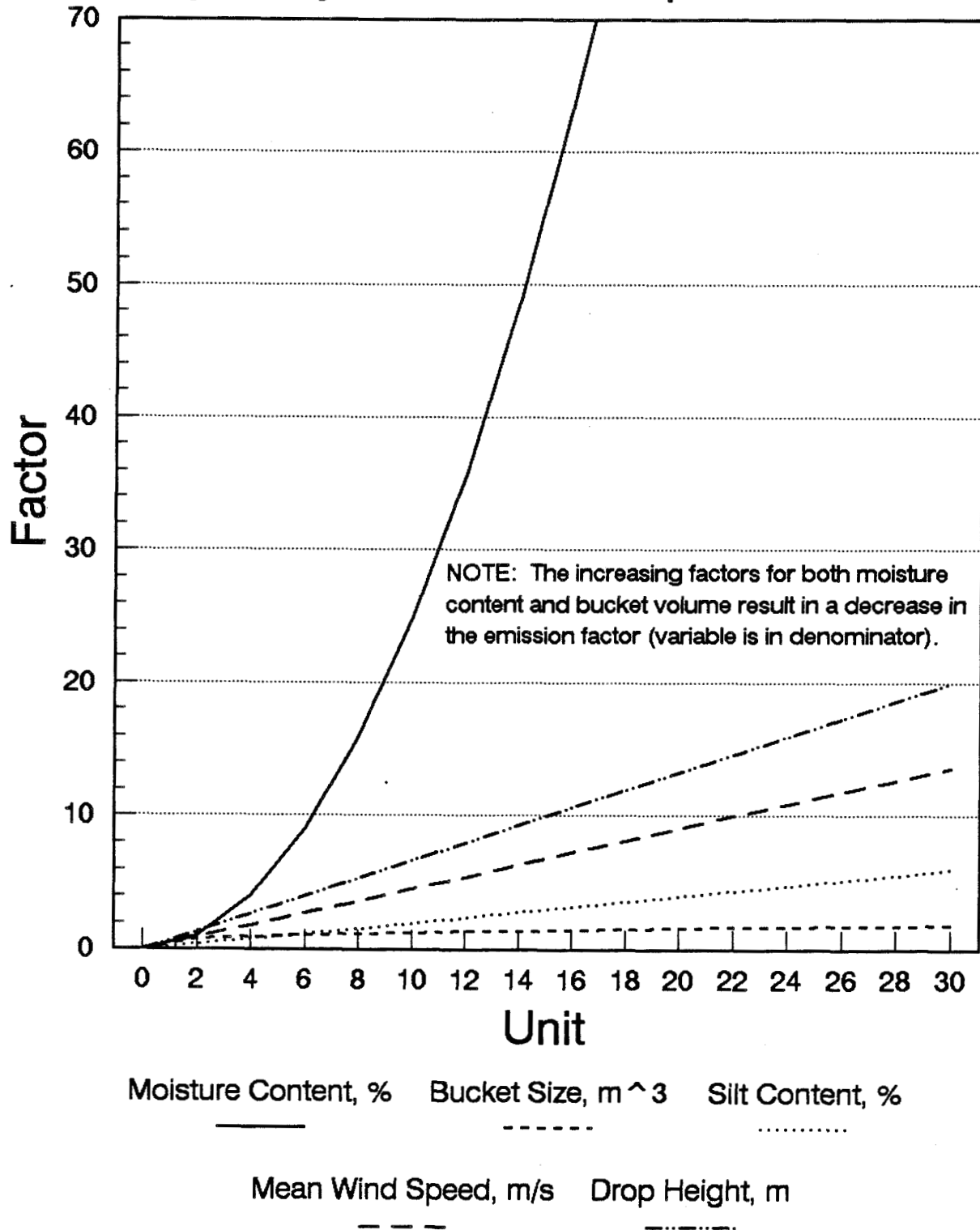
<u>RANK</u>	<u>VARIABLE</u>	<u>INCREASE RESULTS IN:</u>
1	M, Moisture Content	Decrease
2	H, Drop Height	Increase
3	U, Mean Wind Speed	Increase
4	s, Silt Content	Increase
5	Y, Bucket Volume	Decrease

VOCs are assumed to be distributed homogeneously through the soil excavated during construction of the test pit. As with the well drilling, a worse case for VOC emission has been developed by assuming all of the VOCs are completely volatilized and emitted during the test pit construction.

Major Excavation: A major excavation requires the use of several types of heavy equipment including scrapers and front-shovel excavators. As discussed earlier, the activity chosen to represent a major excavation is the construction of the french drain at the 881 Hillside location. Construction of the french drain will be stepwise with the following major activities:

FIGURE 2

Sensitivity Analysis - Backhoe Operations Model



1. Topsoil removal by scraper, transportation by scraper and unloading by scraper.
2. Trench excavation by front-shovel excavator.

These major activities are modeled for total particulate dust emission factors as follows (Tistinic, 1984):

Removal by scraper

$$\text{Emission (kg/Mg)} = 0.019 \text{ kg/Mg}$$

Transportation by scraper

$$\text{Emission (kg/VKT)} = 2.2 \text{ E-6 (s)}^{1.4} (\text{W})^{2.5}$$

s = silt content, %

W = mean vehicle weight, Mg

Unloading by scraper (Batch Drop)

$$\text{Emission (kg/Mg)} = K (0.0009) \frac{(s/5) (U/2.2) (H/1.5)}{(M/2)^2 (Y/4.6)^{33}}$$

Note: Variables defined in discussion for minor excavation.

Trench excavation by front-shovel excavator (Batch Drop)

(same as unloading by scraper)

The values for variables in the transportation and unloading by scraper models were estimated from various sources. Again, silt content, moisture content, and mean wind speed were estimated as 50 percent, 10 percent, and 4.7 m/s, respectively. The bucket volume for the scraper was estimated as 10.7 m³ (Caterpillar Model 621E) and the drop height estimated as 1 m.

The variables for the excavation by front shovel excavator were estimated as discussed for the scraper model with the exception that the bucket volume was estimated as 3.5 m³ (Caterpillar Model 245B) (Caterpillar, 1989), and the drop height estimated as 2 m.

A sensitivity analysis was unnecessary for the removal by scraper model; however, a simple sensitivity analysis was performed on the transportation model. Figure 3 demonstrates that changes in mean vehicle weight have the greatest impact on the total particulate emission factor; however, an increase in either variable (silt content or mean vehicle weight) results in an increase in the total particulate emission factor.

A sensitivity analysis for the batch drop equation used to model both unloading by scraper and excavation by front-shovel excavator was discussed in the section for minor excavation.

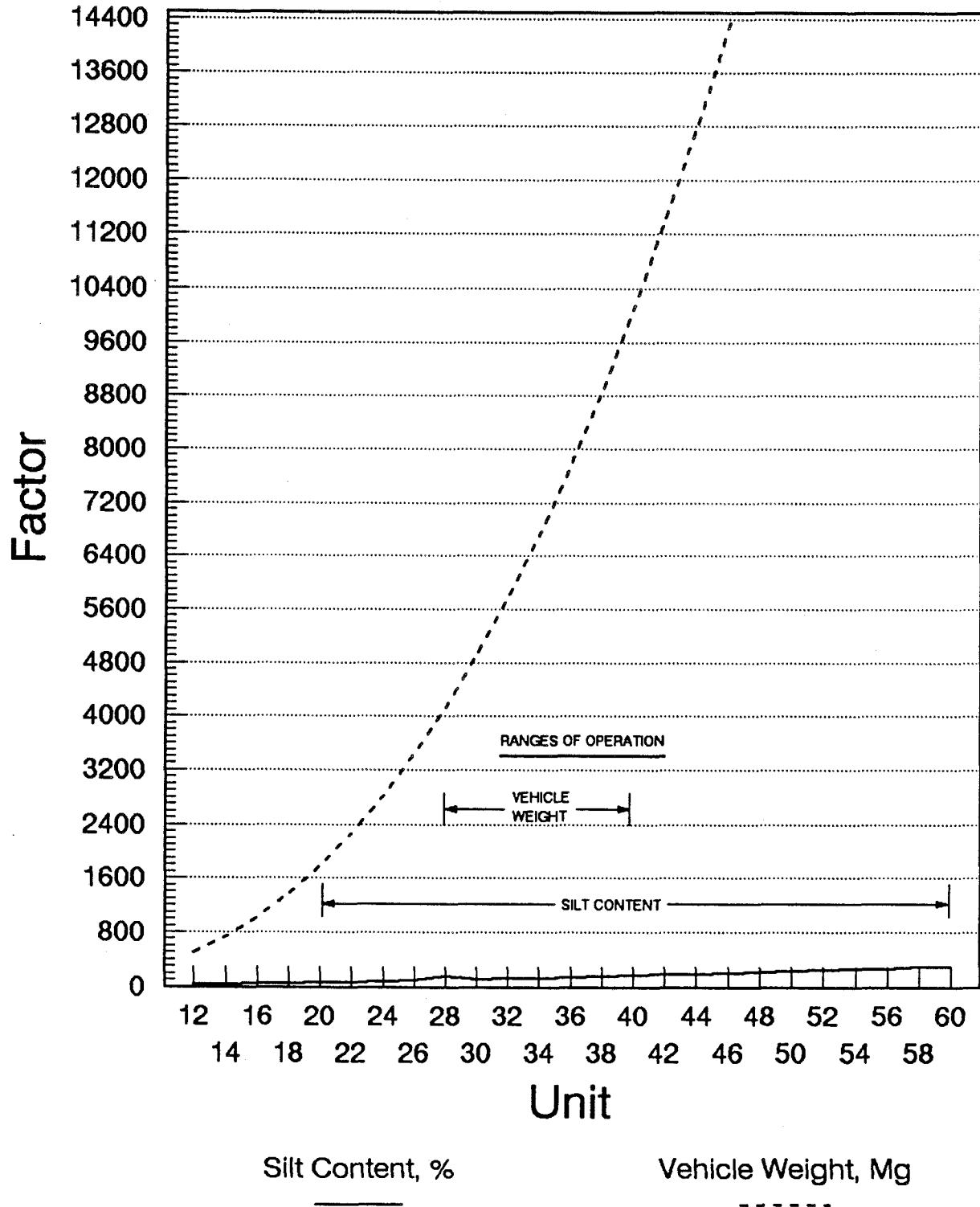
Assumptions used for VOCs emissions are the same as those discussed under minor excavation.

A.2.3 REFERENCES

1. Tistinic, Tom. Memorandum. Public Health Engineer, Colorado Department of Health Subject: Fugitive Particulate Emissions, July 2, 1984 (Attachment A.2.1).
2. Soil Conservation Service, 1980. Soil Survey of Golden Area, Colorado, United States Department of Agriculture,
3. Caterpillar Performance Handbook, 20th Edition, October 1989. Peoria, IL, Caterpillar, Inc.

FIGURE 3

Sensitivity Analysis - Scraper Trans. Model



ATTACHMENT A.2.1

M E M O R A N D U M

To: All Interested Parties
Through: Colorado Department of Health, Air Pollution Control Division
From: Tom Tistic, Public Health Engineer
Subject: Fugitive Particulate Emissions
Date: July 2, 1984

Attached find the updated compilation of fugitive particulate emission factors recommended for use in estimating emissions from mining activities. To avoid confusion and maintain consistency, it is recommended that the EPA's Compilation of Air Pollutant Emission Factors (AP-42) be used whenever applicable. Those Sections of AP-42 applicable to this compilation are attached for easy reference. In some cases, we recommend additional factors when one is needed and is not included in AP-42.

When estimating emissions the factors for the specific material being mined should be used. For instance, when processing a coal mine permit, use all factors listed in the Western Surface Coal Mining Section. However, if no emission factor for a certain activity is given in a specific material section, you may refer to another. For example, when processing a stone quarrying permit, to obtain a factor for vehicle traffic on unpaved roads you will refer to the Unpaved Roads section.

The factors are grouped into nine major sections as follows:

- I. Emission Factors applicable to all Mining Operations
- II. Western Surface Coal Mining
- III. Sand and Gravel Processing
- IV. Stone Quarrying and Processing
- V. Metallic Minerals Processing (use for molybdenum and uranium processing)
- VI. Unpaved Roads
- VII. Paved Roads
- VIII. Aggregate Handling and Storage Piles

IX. Appendices

- A. Particle Size Distributions
- B. Control Efficiencies
- C. Useful Weights and Measures
- D. Meteorological Data
- E. Additional Factors

Following some sections are additional factors, particle size distributions and other data recommended for use by the APCD.

These factors should be used with the following provisos:

1. The factors should be combined with a deposition function in the model. For this reason, emissions should be estimated for a minimum of three particle sizes, e.g. <30 um (or TSP), <15 or <10, and <5 or <2.5. Of course, the more detailed the distribution, the greater the model accuracy.
2. The factors do not consider any reduction for pit retention. Preliminary data indicate under certain stabilities we could experience no pit retention; therefore, pit retention should not be considered until further data is presented to the contrary. (1)
3. Days with rain (\geq .01 inches), snow cover and temperatures below freezing (during the entire working day) should be considered when calculating annual emissions.
4. Generally speaking, the factors were developed based on those particles collected by the hi-vol sampler, which are considered to be less than 30 microns in size.
5. Total annual emissions should be calculated for the estimated year of greatest activity. Naturally some factors such as crushing should be used in combination with total annual work days; and some factors such as wind erosion should be applied 365 days/year.
6. Data from AP-42 unless otherwise indicated. Other references indicated with parentheses, (), following the factor.

SECTION I

EMISSION FACTORS APPLICABLE TO ALL MINING OPERATIONS

Activity	Material	TSP ($\leq 30 \mu m$)	$\leq 15 \mu m$	$\leq 2.5 \mu m$	Units	Variables/Comments
<u>Topsoil Handling</u>						
a. Removal by scraper	Topsoil	0.058	0.038 ①	0.0103 ①	lb/T	
b. Hauling by scraper	All	$2.7 \times 10^{-5} (s) 1.3 (w) 2.4$	$6.2 \times 10^{-6} (s) 1.4 (w) 2.5$	0.026 X TSP lb/VMT	lb/VMT	s-Silt=7.2-25.2% (16.4 mean) W-Weight=36-70 tons (53.8 mean)
c. Unloading by scraper	Topsoil	0.04	0.026 ①	0.007 ①	lb/T	
d. Storage	All exposed Areas	0.38	0.25 ①	0.068 ①	T/(acre)(yr)	
<u>Drilling</u>						
	Overburden or Ore	1.3	0.56 ②	0.0325 ②	lb/hole	
	Coal	0.22	0.095 ②	0.0055 ②	lb/hole	
	Rock	0.26 (2)	0.112 ②	0.0065 ②	lb/hole	OR 0.0013 lb/ton quarried (3)
<u>Blasting</u>						
	All	$\frac{961(A) 0.8}{(D) 1.8(H) 1.9}$	$\frac{2550(A) 0.6}{(D) 1.5 (H) 2.3}$	(0.03)(TSP)	lb/blast	A=Area=1,000-100,000 ft. ² (19,000 mean) D=Depth=20-135 ft (25.9 mean) H=Holature=7.2-38% (17.2 mean)
Overburden Removal	Use applicable factors in coal Mining Section for either dragline, bulldozer or scraper.					

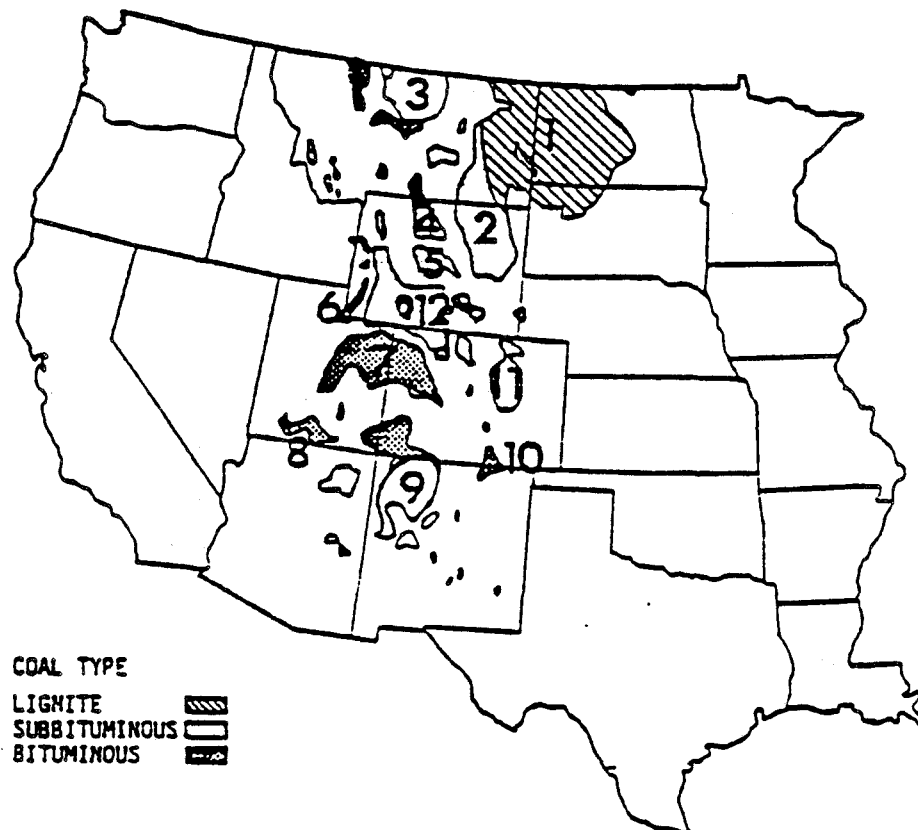
- ① Used batch load out particle size distribution (See Section VIII)
- ② Used average coal mine particle size distribution (See Appendix A)

SECTION II

8.24 WESTERN SURFACE COAL MINING

8.24.1 General¹

There are 12 major coal fields in the western states (excluding the Pacific Coast and Alaskan fields), as shown in Figure 8.24-1. Together, they account for more than 64 percent of the surface minable coal reserves



	Coal field	Stripable reserves (10 ⁶ tons)
1	Fort Union	23,529
2	Powder River	56,727
3	North Central	All underground
4	Bighorn Basin	All underground
5	Wind River	3
6	Hams Fork	1,000
7	Uinta	308
8	Southwestern Utah	224
9	San Juan River	2,318
10	Raton Mesa	All underground
11	Denver	All underground
12	Green River	2,120

Figure 8.24-1. Coal fields of the western U.S.³

in the United States.² The 12 coal fields have varying characteristics which may influence fugitive dust emission rates from mining operations, including overburden and coal seam thicknesses and structure, mining equipment, operating procedures, terrain, vegetation, precipitation and surface moisture, wind speeds and temperatures. The operations at a typical western surface mine are shown in Figure 8.24-2. All operations that involve movement of soil, coal, or equipment, or exposure of erodible surfaces, generate some amount of fugitive dust.

The initial operation is removal of topsoil and subsoil with large scrapers. The topsoil is carried by the scrapers to cover a previously mined and regraded area as part of the reclamation process or is placed in temporary stockpiles. The exposed overburden, the earth which is between the topsoil and the coal seam, is leveled, drilled and blasted. Then the overburden material is removed down to the coal seam, usually by a dragline or a shovel and truck operation. It is placed in the adjacent mined cut, forming a spoils pile. The uncovered coal seam is then drilled and blasted. A shovel or front end loader loads the broken coal into haul trucks, and it is taken out of the pit along graded haul roads to the tipple, or truck dump. Raw coal sometimes may be dumped onto a temporary storage pile and later rehandled by a front end loader or bulldozer.

At the tipple, the coal is dumped into a hopper that feeds the primary crusher, then is conveyed through additional coal preparation equipment such as secondary crushers and screens to the storage area. If the mine has open storage piles, the crushed coal passes through a coal stacker onto the pile. The piles, usually worked by bulldozers, are subject to wind erosion. From the storage area, the coal is conveyed to a train loading facility and is put into rail cars. At a captive mine, coal will go from the storage pile to the power plant.

During mine reclamation, which proceeds continuously throughout the life of the mine, overburden spoils piles are smoothed and contoured by bulldozers. Topsoil is placed on the graded spoils, and the land is prepared for revegetation by furrowing, mulching, etc. From the time an area is disturbed until the new vegetation emerges, all disturbed areas are subject to wind erosion.

8.24.2 Emissions

Predictive emission factor equations for open dust sources at western surface coal mines are presented in Tables 8.24-1 and 8.24-2. Each equation is for a single dust generating activity, such as vehicle traffic on unpaved roads. The predictive equation explains much of the observed variance in emission factors by relating emissions to three sets of source parameters: 1) measures of source activity or energy expended (e.g., speed and weight of a vehicle traveling on an unpaved road); 2) properties of the material being disturbed (e.g., suspendable fines in the surface material of an unpaved road); and 3) climate (in this case, mean wind speed).

The equations may be used to estimate particulate emissions generated per unit of source extent (e.g., vehicle distance traveled or mass of material transferred).

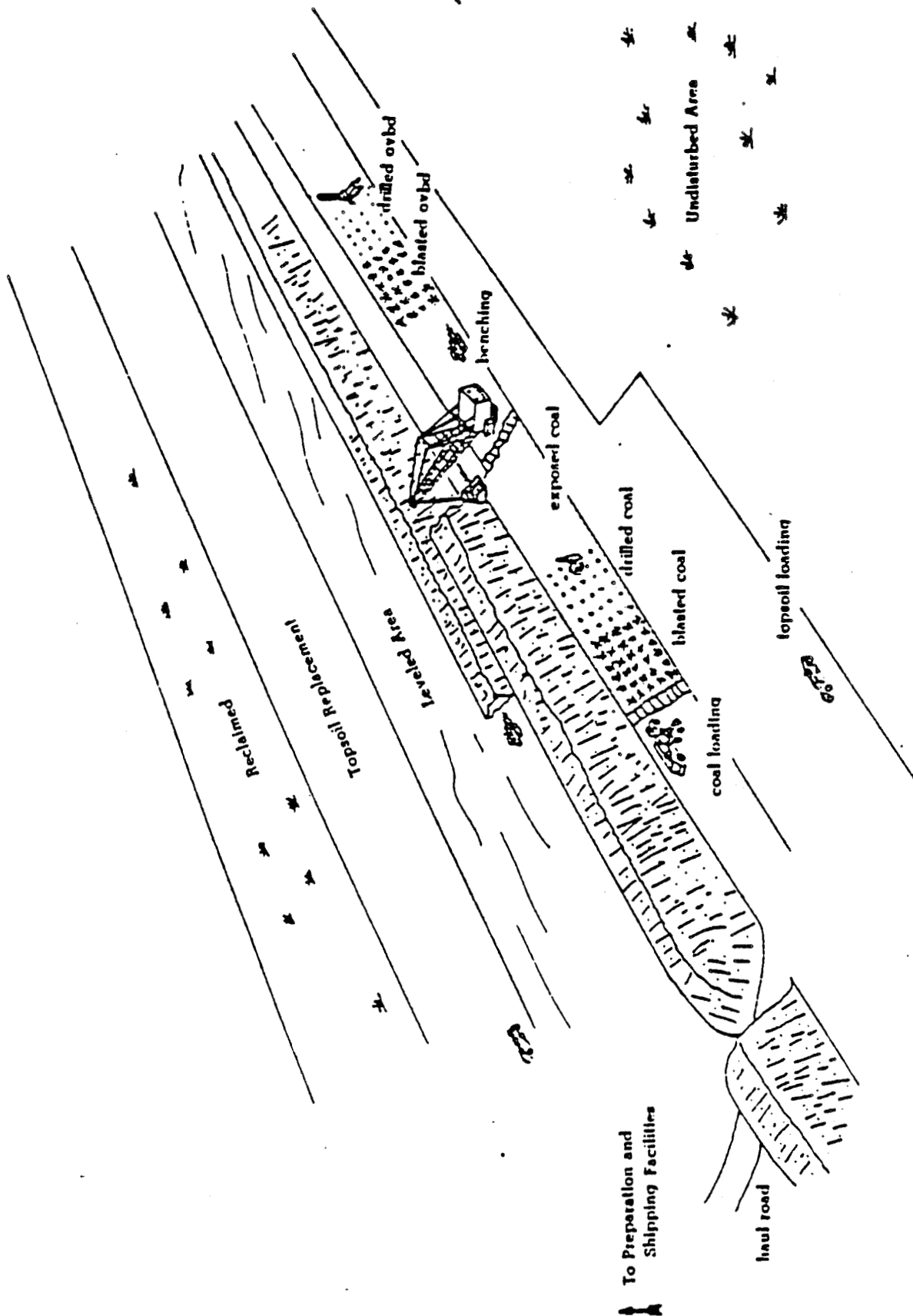


Figure 8.24-2. Operations at typical western surface coal mines.

TABLE 8.24-1. EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES (METRIC UNITS)^a

Operation	Material	Emissions by particle size range (aerodynamic diameter) ^{b,c}		Units	Emission Factor Rating
		TSP (< 30 µm)	< 2.5 µm/TSP ^d		
Blasting	Coal or overburden	$\frac{344 (A)^{0.8}}{(D)^{1.8} (H)^{1.9}}$	$\frac{811 (A)^{0.6}}{(D)^{1.3} (H)^{2.3}}$	kg/blast	B
Truck loading	Coal	$\frac{0.580}{(H)^{1.2}}$	$\frac{0.0596}{(H)^{0.9}}$	kg/Hg	B
Pullblasting	Coal	$\frac{35.6 (s)^{1.2}}{(H)^{1.3}}$	$\frac{8.45 (s)^{1.5}}{(H)^{1.4}}$	kg/hr	A
Dragnet	Overburden	$\frac{2.6 (s)^{1.2}}{(H)^{1.3}}$	$\frac{0.45 (s)^{1.5}}{(H)^{1.4}}$	kg/hr	B
Scrapers (travel mode)	Overburden	$\frac{0.0046 (d)^{1.1}}{(H)^{0.3}}$	$\frac{0.0029 (d)^{0.7}}{(H)^{0.3}}$	kg/m ²	B
Grading		$9.6 \times 10^{-6} (s)^{1.3} (v)^{2.4}$	$2.2 \times 10^{-6} (s)^{1.4} (v)^{2.5}$	kg/VKT	A
Vehicle traffic (light/medium duty)		$\frac{0.0034 (S)^{2.5}}{(H)^{0.3}}$	$\frac{0.0056 (S)^{2.0}}{(H)^{0.3}}$	kg/VKT	B
Haul trucks		$\frac{1.63}{(H)^{0.3}}$	$\frac{1.05}{(H)^{0.3}}$	kg/VKT	B
Active storage pile (wind erosion and maintenance)	Coal	$0.0019 (v)^{3.4} (L)^{0.2}$	$0.0014 (v)^{3.5}$	kg/VKT	A
		1.8 u	NA	$\frac{kg}{(hectare)(hr)}$	C ^e

^a All equations are from Reference 1, except for coal storage pile equation from Reference 4. TSP = total suspended particulate. VKT = vehicle miles traveled. VMT = vehicle kilometers traveled. NA = not available.

^b TSP denotes what is measured by a standard high volume sampler (see Section 11.2).

^c Symbols for equations:

A = area blasted (m²)
H = material moisture content (%)
D = hole depth (m)
s = material silt content (%)
u = wind speed (m/sec)
v = road surface silt loading (g/m²)
L = road surface silt loading (g/m²)
^d Multiply the TSP predictive equation by this fraction to determine emissions in the < 2.5 µm size range.
^e Rating applicable to Mine Types I, II and IV (see Tables 8.24-5 and 8.24-6).

TABLE 8.24-2. EMISSION FACTOR EQUATIONS FOR UNCONTROLLED OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES (ENGLISH UNITS)^a

Operation	Material	Emissions by particle size range (aerodynamic diameter) ^{b,c}		Units	Emission Factor Rating
		TSP (< 30 μ m)	< 2.5 μ m/TSP ^d		
Blasting	Coal or overburden	$\frac{961 (A)^{0.8}}{(D)^{1.8} (H)^{1.9}}$	$\frac{2,350 (A)^{0.6}}{(D)^{1.5} (H)^{2.3}}$	lb/blast	B
Truck loading	Coal	$\frac{1.16}{(H)^{1.2}}$	$\frac{0.119}{(H)^{0.9}}$	lb/T	B
Bulldozing	Coal	$\frac{78.4 (a)^{1.2}}{(H)^{1.3}}$	$\frac{18.6 (a)^{1.5}}{(H)^{1.6}}$	lb/hr	B
	Overburden	$\frac{5.7 (a)^{1.2}}{(H)^{1.3}}$	$\frac{1.0 (a)^{1.5}}{(H)^{1.6}}$	lb/hr	B
Dragline	Overburden	$\frac{0.0021 (d)^{1.1}}{(H)^{0.3}}$	$\frac{0.0021 (d)^{0.7}}{(H)^{0.3}}$	lb/yd ³	B
Scrapers (travel mode)		$2.7 \times 10^{-5} (a)^{1.3} (W)^{2.4}$	$6.2 \times 10^{-6} (a)^{1.4} (W)^{2.5}$	lb/VMT	A
Grading		$0.040 (S)^{2.5}$	$0.051 (S)^{2.0}$	lb/VMT	B
Vehicle traffic (light/medium duty)		$\frac{5.79}{(H)^{4.0}}$	$\frac{3.72}{(H)^{3.3}}$	lb/VMT	B
Haul trucks		$0.0067 (w)^{3.4} (L)^{0.2}$	$0.0051 (w)^{3.5}$	lb/VMT	A
Active storage pile (wind erosion and maintenance)	Coal	1.6 u	NA	$\frac{lb}{(acre)(hr)}$	C ^e

^a All equations are from Reference 1, except for coal storage pile equation from Reference 4. TSP = total suspended particulate. VMT = vehicle miles traveled. VMT = vehicle kilometers traveled. NA = not available.

^b TSP denotes what is measured by a standard high volume sampler (see Section 11.2).

^c Symbols for equations:

A = area blasted (ft²)
M = material moisture content (%)
D = hole depth (ft)
a = material silt content (%)
u = wind speed (m/sec)
L = road surface silt loading (g/m²)

^d Multiply the TSP predictive equation by this fraction to determine emissions in the < 2.5 μ m size range.
^e Rating applicable to Mine Types I, II and IV (see Tables 8.24-5 and 8.24-6).

The equations were developed through field sampling various western surface mine types and are thus applicable to any of the surface coal mines located in the western United States.

In Tables 8.24-1 and 8.24-2, the assigned quality ratings apply within the ranges of source conditions that were tested in developing the equations, given in Table 8.24-3. However, the equations are derated one letter value (e.g., A to B) if applied to eastern surface coal mines.

TABLE 8.24-3. TYPICAL VALUES FOR CORRECTION FACTORS APPLICABLE TO THE PREDICTIVE EMISSION FACTOR EQUATIONS^a

Source	Correction factor	Number of test samples	Range	Geometric mean	Units
Blasting	Moisture	5	7. - 38	17.2	%
	Depth	18	- 41	7.9	m
			2 - 135	25.9	ft
	Area	18	9 - 9,000	1,800	m ²
Coal loading Bulldozers			1,000 - 100,000	19,000	ft ²
	Moisture	7	6.5 - 38	17.8	%
	Coal	3	4.0 - 22.0	10.4	%
	Silt	3	6.0 - 11.3	8.6	%
Overburden	Moisture	8	2.2 - 16.8	7.9	%
	Silt	8	3.8 - 15.1	6.9	%
Dragline	Drop distance	19	1.5 - 30	8.6	m
			5 - 100	28.1	ft
Scraper	Moisture	7	0.2 - 16.3	3.2	%
	Silt	10	7.2 - 25.2	16.4	%
	Weight	15	33 - 64	48.8	Mg
Grader			36 - 70	53.8	tons
	Speed	7	8.0 - 19.0	11.4	kph
Light/medium duty vehicles			5.0 - 11.8	7.1	mph
	Moisture	7	0.9 - 1.7	1.2	%
Haul truck	Wheels	29	6.1 - 10.0	8.1	number
	Silt loading	26	3.8 - 254	40.8	g/m ²
			34 - 2,270	364	lb/acre

^a Reference 1.

In using the equations to estimate emissions from sources in a specific western surface coal mine, it is necessary that reliable values for correction parameters be determined for the specific sources of interest, if the assigned quality ratings of the equations are to apply. For example, actual silt content of coal or overburden measured at a facility

should be used instead of estimated values. In the event that site specific values for correction parameters cannot be obtained, the appropriate geometric mean values from Table 8.24-3 may be used, but the assigned quality rating of each emission factor equation is reduced by one level (e.g., A to B).

Emission factors for open dust sources not covered in Table 8.24-3 are in Table 8.24-4. These factors were determined through source testing at various western coal mines.

The factors in Table 8.24-4 for mine locations I through V were developed for specific geographical areas. Tables 8.24-5 and 8.24-6 present characteristics of each of these mines (areas). A "mine specific" emission factor should be used only if the characteristics of the mine for which an emissions estimate is needed are very similar to those of the mine for which the emission factor was developed. The other (nonspecific) emission factors were developed at a variety of mine types and thus are applicable to any western surface coal mine.

As an alternative to the single valued emission factors given in Table 8.24-4 for train or truck loading and for truck or scraper unloading, two empirically derived emission factor equations are presented in Section 11.2.3 of this document. Each equation was developed for a source operation (i.e., batch drop and continuous drop, respectively), comprising a single dust generating mechanism which crosses industry lines.

Because the predictive equations allow emission factor adjustment to specific source conditions, the equations should be used in place of the factors in Table 8.24-4 for the sources identified above, if emission estimates for a specific western surface coal mine are needed. However, the generally higher quality ratings assigned to the equations are applicable only if 1) reliable values of correction parameters have been determined for the specific sources of interest and 2) the correction parameter values lie within the ranges tested in developing the equations. Table 8.24-3 lists measured properties of aggregate materials which can be used to estimate correction parameter values for the predictive emission factor equations in Chapter 11, in the event that site specific values are not available. Use of mean correction parameter values from Table 8.24-3 reduces the quality ratings of the emission factor equations in Chapter 11 by one level.

TABLE 8.24-4. UNCONTROLLED PARTICULATE EMISSION FACTORS FOR
OPEN DUST SOURCES AT WESTERN SURFACE COAL MINES

Source	Material	Mine location ^a	TSP emission factor ^b	Units	Emission Factor Rating
Drilling	Overburden	Any	1.3	lb/hole	B
			0.59	kg/hole	B
	Coal	V	0.22	lb/hole	E
			0.10	kg/hole	E
Topsoil removal by scraper	Topsoil	Any	0.058	lb/T	E
			0.029	kg/Hg	E
		IV	0.44	lb/T	D
			0.22	kg/Hg	D
Overburden replacement	Overburden	Any	0.012	lb/T	C
			0.0060	kg/Hg	C
Truck loading by power shovel (batch drop) ^c	Overburden	V	0.037	lb/T	C
			0.018	kg/Hg	C
Train loading (batch or continuous drop) ^c	Coal	Any	0.028	lb/T	D
			0.014	kg/Hg	D
		III	0.0002	lb/T	D
			0.0001	kg/Hg	D
Bottom dump truck unloading (batch drop) ^c	Overburden	V	0.002	lb/T	E
			0.001	kg/T	E
	Coal	IV	0.027	lb/T	E
			0.014	kg/Hg	E
		III	0.005	lb/T	E
			0.002	kg/Hg	E
		II	0.020	lb/T	E
			0.010	kg/Hg	E
		I	0.014	lb/T	D
			0.0070	kg/Hg	D
		Any	0.066	lb/T	D
			0.033	kg/Hg	D
End dump truck unloading (batch drop) ^c	Coal	V	0.007	lb/T	E
			0.004	kg/Hg	E
Scraper unloading (batch drop) ^c	Topsoil	IV	0.04	lb/T	C
			0.02	kg/Hg	C
Wind erosion of exposed areas	Seeded land, stripped overburden, graded overburden	Any	0.38	$\frac{T}{(\text{acre})(\text{yr})}$	C
			0.85	$\frac{Hg}{(\text{hectare})(\text{yr})}$	C

^a Roman numerals I through V refer to specific mine locations for which the corresponding emission factors were developed (Reference 4). Tables 8.24-4 and 8.24-5 present characteristics of each of these mines. See text for correct use of these "mine specific" emission factors. The other factors (from Reference 5 except for overburden drilling from Reference 1) can be applied to any western surface coal mine.

^b Total suspended particulate (TSP) denotes what is measured by a standard high volume sampler (see Section 11.2).

^c Predictive emission factor equations, which generally provide more accurate estimates of emissions, are presented in Chapter 11.

TABLE 8.24-5. GENERAL CHARACTERISTICS OF SURFACE COAL MINES REFERRED TO IN TABLE 8.24-4^a

Mine	Location	Type of coal mined	Terrain	Vegetative cover	Surface soil type and erodibility index	Mean wind speed m/s mph	Mean annual precipitation cm in.
I	N.W. Colorado	Subbitum.	Moderately steep	Moderate, sagebrush	Clayey, loamy (71)	2.3 5.1	38 15
II	S.W. Wyoming	Subbitum.	Semirugged	Sparse, sagebrush	Arid soil with clay and alkali or carbonate accumulation (86)	6.0 13.4	36 14
III	S.E. Montana	Subbitum.	Gently rolling to semirugged	Sparse, moderate, prairie grassland	Shallow clay loamy deposits on bedrock (47)	4.8 10.7	28 - 41 11 - 16
IV	Central North Dakota	Lignite	Gently rolling	Moderate, prairie grassland	Loamy, loamy to sandy (71)	5.0 11.2	43 17
V	N.E. Wyoming	Subbitum.	Flat to gently rolling	Sparse, sagebrush	Loamy, sandy, clayey, and clay loamy (102)	6.0 13.4	36 14

^a Reference 4.

TABLE 8.24-6. OPERATING CHARACTERISTICS OF THE COAL MINES
REFERRED TO IN TABLE 8.24-4^a

Parameter	Required information	Units	Mines				
			I	II	III	IV	V
Production rate	Coal mined	10 ⁶ T/yr	1.13	5.0	9.5	3.8	12.0 ^b
Coal transport	Avg. unit train frequency	per day	NA	NA	2	NA	2
Stratigraphic data	Overburden thickness	ft	21	80	90	65	35
	Overburden density	lb/yds	4000	3705	3000	-	-
	Coal seam thicknesses	ft	9.35	15.9	27	2.4, 8	70
	Parting thicknesses	ft	50	15	NA	32, 16	NA
	Spoils bulking factor	X	22	24	25	20	-
Coal analysis data	Active pit depth	ft	52	100	114	80	105
	Moisture	%	10	18	24	38	30
	Ash	%, wet	8	10	8	7	6
	Sulfur	%, wet	0.46	0.59	0.75	0.65	0.48
	Heat content	Btu/lb	11000	9632	8628	8500	8020
Surface disposition	Total disturbed land	acre	168	1030	2112	1975	217
	Active pit	acre	34	202	87	-	71
	Spoils	acre	57	326	144	-	100
	Reclaimed	acre	100	221	950	-	100
	Barren land	acre	-	30	455	-	-
Storage	Associated disturbances	acre	12	186	476	-	46
	Capacity	ton	NA	NA	-	NA	48000
	Frequency, coal	per week	4	4	3	7	7 ^b
	Frequency, overburden	per week	3	0.5	3	NA	7 ^b
	Area blasted, coal	ft ²	16000	40000	-	30000	-
Blasting	Area blasted, overburden	ft ²	20000	-	-	NA	-

^a Reference 4. NA = not applicable. Dash = not available.

^b Estimate.

References for Section 8.24

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2. Reserve Base of U. S. Coals by Sulfur Content: Part 2, The Western States, IC8693, Bureau of Mines, U. S. Department of the Interior, Washington, DC, 1975.
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4. K. Axetell, Survey of Fugitive Dust from Coal Mines, EPA-908/1-78-003, U. S. Environmental Protection Agency, Denver, CO, February 1978.
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SECTION II

WESTERN SURFACE COAL MINING

Emissions in lbs/T - assumes moisture content of 4% or greater (See Section V)

Activity	<30 um	<15 um ①	<10 um ①	<5 um ①	<2.5 um ①
Primary Crushing	.02 (4)	.0086	.0056	.002	.0005
Secondary Crushing	.06 (4)	.0258	.0168	.006	.0015
Tertiary Crushing	.18 (5)	.0774	.0504	.018	.0045
Screening	.10 (4)	.043	.028	.010	.0025

① Used "overall" particle size distribution for coal mining operation (See Appendix A)

8.19.1 SAND AND GRAVEL PROCESSING

8.19.1.1 Process Description¹⁻²

Deposits of sand and gravel, the consolidated granular materials resulting from the natural disintegration of rock or stone, are generally found in banks and pits and in subterranean and subaqueous beds. Sand and gravel are products of the weathering of rocks and are mostly silica. Often, varied amounts of iron oxides, mica, feldspar and other minerals are present. Deposits are common throughout the country.

Depending upon the location of the deposit, the materials are excavated with power shovels, draglines, cableways, suction dredge pumps or other apparatus. Lightcharge blasting may occasionally be necessary to loosen the deposit. The materials are transported to the processing plant by suction pump, earth mover, barge, truck or other means. The processing of sand and gravel for a specific market involves the use of different combinations of washers, screens and classifiers to segregate particle sizes; crushers to reduce oversize material; and storage and loading facilities.

8.19.1.2 Emissions and Controls¹

Dust emissions occur during conveying, screening, crushing and storing operations. Generally, these materials are wet or moist when handled, and process emissions are often negligible. (If processing is dry, expected emissions could be similar to those shown in Section 8.19.2, Crushed Stone.) Considerable emissions may occur from vehicles hauling materials to and from a site. Open dust source emission factors for such sand and gravel processing operations have been determined through source testing at various sand and gravel plants and, in some instances, through additional extrapolations, and are presented in Table 8.19.1-1.

As an alternative to the single valued emission factors given in Table 8.19.1-1, empirically derived emission factor equations are presented in Chapter 11 of this document. Each equation was developed for a single source operation or dust generating mechanism which crosses industry lines, such as vehicular traffic on unpaved roads. The predictive equation explains much of the observed variance in measured emission factors by relating emissions to different source parameters. These parameters may be grouped as 1) measures of source activity or expended energy (e.g., the speed and weight of a vehicle traveling on an unpaved road); 2) properties of the material being disturbed (e.g., the content of suspendable fines in the surface material on an unpaved road); and 3) climate (e.g., number of precipitation free days per year, when emissions tend to a maximum).

Because predictive equations allow for emission factor adjustment to specific conditions, they should be used instead of the factors given in Table 8.19.1-1 whenever emission estimates are needed for sources in a specific sand and gravel processing facility. However, the generally higher quality ratings assigned to the equations are applicable only if 1) reliable values of correction parameters have been determined for the specific

TABLE 8.19.1-1. UNCONTROLLED PARTICULATE EMISSION FACTORS FOR OPEN DUST SOURCES
AT SAND AND GRAVEL PROCESSING PLANTS^a

Uncontrolled dry operation	Emissions by particle size range (aerodynamic diameter) ^b				Emission Factor Rating
	Total particulate	TSP < ~30 µm	< 10 µm	Units	
Continuous drop ^c					
Transfer station					
Pile formation - stacker	0.014 (0.029) NA	NA 0.065 (0.13)	NA 0.03 (0.06) ^d	kg/Hg (lb/ton) kg/Hg (lb/ton)	E E
Batch drop ^c					
Bulk loading	0.12 (0.24)	0.028 (0.056) ^e	0.0012 (0.0024) ^e	kg/Hg (lb/ton)	E
Active storage piles ^{f,g,h}					
Active day	NA	14.8 (13.2)	7.1 (6.3) ^d	kg/hectare/day (lb/acre/day) ⁱ	D
Inactive day (wind erosion only)	NA	3.9 (3.5)	1.9 (1.7) ^d	kg/hectare/day (lb/acre/day) ⁱ	D
Normal mix of active and inactive day ^j	NA	11.6 (10.4)	5.6 (5.0) ^d	kg/hectare/day (lb/acre/day) ⁱ	D
Vehicle traffic on unpaved road ^c					
Heavy duty vehicle	14.7 (52.0)	9.31 (33.0) ^e	0.87 (3.1) ^e	kg/VMT (lb/VMT)	C

- ^a NA = not available. TSP = total suspended particulate. VMT = vehicle kilometers traveled. VMT = vehicle miles traveled. Predictive emission factor equations, which generally provide more accurate estimates of emissions, are presented in Chapter 11.
- ^b Total particulate is airborne particles of all sizes in the source plume. TSP is what is measured by a standard high volume sampler (see Section 11.2).
- ^c Reference 3.
- ^d Extrapolation of data using k factors for appropriate operation from Chapter 11.
- ^e For physical, not aerodynamic, diameter.
- ^f Reference 4.
- ^g Includes the following distinct source operations in the storage cycle: 1) loading of aggregate onto storage piles (batch or continuous drop operations), 2) equipment traffic in storage areas, 3) wind erosion of pile surfaces and ground areas among piles, and 4) loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).
- ^h 8 to 12 hours of activity per 24 hours.
- ⁱ Pounds/acre of storage (includes areas among piles)/day.
- ^j Assumes a 5 day work week.

sources of interest and 2) the correction parameter values lie within the ranges tested in developing the equations. Chapter 11 lists measured properties of aggregate materials used in industries relating to the sand and gravel industry, which can be used to approximate correction parameter values for the predictive emission factor equations, in the event that site specific values are not available. Use of mean correction parameter values from Chapter 11 reduces the quality ratings of the emission factor equations by at least one level.

Since emissions from sand and gravel operations are usually in the form of fugitive dust, control techniques applicable to fugitive dust sources are appropriate. Control techniques most successfully used¹ for haul roads are application of dust suppressants, paving, route modifications, soil stabilization, etc.; for conveyors, covering and wet dust suppression; for storage piles, wet dust suppression, windbreaks, enclosure and soil stabilizers; and for conveyor and batch transfer points (loading, unloading, etc.), wet suppression and various methods to reduce freefall distances (e.g., telescopic chutes, stone ladders and hinged boom stacker conveyors).

Wet suppression techniques include application of water, chemicals or foam, usually at conveyor feed and discharge points. Such spray systems at transfer points and on material handling operations are estimated to reduce emissions 70 to 95 percent.⁵ Spray systems can also reduce loading and wind erosion emissions from storage piles of various materials 80 to 90 percent.⁶ Control efficiencies depend upon local climatic conditions, source properties and duration of control effectiveness. Table 11.2.1-2 contains estimates of control efficiency for various emission suppressant methods for haul roads.

References for Section 8.19.1

1. Air Pollution Control Techniques for Nonmetallic Minerals Industry, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.
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3. Fugitive Dust Assessment at Rock and Sand Facilities in the South Coast Air Basin, Southern California Rock Products Association and Southern California Ready Mix Concrete Association, Santa Monica, CA, November 1979.
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5. R. Bohn, et al., Fugitive Emissions from Integrated Iron and Steel Plants, EPA-600/2-78-050, U. S. Environmental Protection Agency, Washington, DC, March 1978.

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SECTION III

SAND AND GRAVEL PROCESSING

For purposes of estimating emissions we have expanded Table 8.19.1-1 as follows:

Uncontrolled Dry Operation	TSP (<30 μ m)	<15 μ m	<10 μ m	<5 μ m	<2.5 μ m	Total Part.
Continuous drop ①						
Transfer station (lb/T)	0.0223	0.0142	0.0107	0.0061	0.0032	0.029
Stacker (lb/T)	0.13	0.083	0.06	0.0355	0.0186	0.169
Batch Drop ① (lb/T)						
	0.056	0.02	0.0024	0.0015	0.0009	0.24
Storage Pile ②						
Active (lb/acre/day)	13.2	8.7	6.3	4.2	2.4	18.0
Inactive (lb/acre/day)	3.5	2.3	1.7	1.1	0.6	4.8
Mix (lb/acre/day)	10.4	6.8	5.0	3.3	1.9	14.2
Haul Trucks ③ (lb/VMT)						
	33.0	13.3	3.1	1.9	1.1	52.0
Crushing, screening & handling ④						
	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Light Duty Vehicles						
	See Unpaved Roads Section VI.					

- ① Calculated using same multipliers or proportions as found in table 11.2.3-2 in Section VIII on Aggregate Handling and Storage Piles.
- ② Assume particle size distribution similar to batch drop (Section VIII) since entrainment due mostly to wind and not a mechanical activity.
- ③ Use particle size multipliers from Section VI Unpaved Roads. In this case will have to use proportions since given 10 μ m value does not conform to given multiplier.
- ④ Negligible. Material is usually moist. However, until we receive a Section 8.19.2 from EPA for purposes of dry processing, or when estimating emissions from processing only, use the values given for stone quarrying and apply moisture corrections.

SECTION IV

8.20 STONE QUARRYING AND PROCESSING

8.20.1 Process Description¹

Rock and crushed stone products are loosened by drilling and blasting them from their deposit beds and are removed with the use of heavy earth-moving equipment. This mining of rock is done primarily in open pits. The use of pneumatic drilling and cutting, as well as blasting and transferring, causes considerable dust formation. Further processing includes crushing, regrinding, and removal of fines.² Dust emissions can occur from all of these operations, as well as from quarrying, transferring, loading, and storage operations. Drying operations, when used, can also be a source of dust emissions.

8.20.2 Emissions¹

As enumerated above, dust emissions occur from many operations in stone quarrying and processing. Although a big portion of these emissions is heavy particles that settle out within the plant, an attempt has been made to estimate the suspended particulates. These emission factors are shown in Table 8.20-1. Factors affecting emissions include the amount of rock processed; the method of transfer of the rock; the moisture content of the raw material; the degree of enclosure of the transferring, processing, and storage areas; and the degree to which control equipment is used on the processes.

Table 8.20-1. PARTICULATE EMISSION FACTORS FOR ROCK-HANDLING PROCESSES
EMISSION FACTOR RATING: C

Type of process	Uncontrolled total ^a		Settled out in plant, %	Suspended emission	
	lb/ton	kg/MT		lb/ton	kg/MT
Dry crushing operations ^{b,c}					
Primary crushing	0.5	0.25	80	0.1	0.05
Secondary crushing and screening	1.5	0.75	60	0.6	0.3
Tertiary crushing and screening (if used)	6	3	40	3.6	1.8
Recrushing and screening	5	2.5	50	2.5	1.25
Fines mill	6	3	25	4.5	2.25
Miscellaneous operations ^d					
Screening, conveying, and handling ^e	2	1			
Storage pile losses ^f					

^aTypical collection efficiencies: cyclone, 70 to 85 percent; fabric filter, 99 percent.

^bAll values are based on raw material entering primary crusher, except those for recrushing and screening, which are based on throughput for that operation.

^cReference 3.

^dBased on units of stored product.

^eReference 4.

^fSee section 11.2.3.

References for Section 8.20

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2. Communication between Resources Research, Incorporated, Reston, Virginia, and the National Crushed Stone Association. September 1969.
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SECTION IV
STONE QUARRYING AND PROCESSING

Emissions in lbs/T - assumes a moisture content of less than 4% (See Section V)

Activity	<30	<15 um ①	<10 um ①	<5 um ①	<2.5 um ①
Primary Crushing	0.1 (1)	0.043	0.028	0.01	0.0025
Secondary Crushing	0.6 (1)	0.258	0.168	0.06	0.015
Tertiary Crushing	3.6 (1)	1.548	1.008	0.36	0.09
Recrush & Screening	2.5 (1)	1.075	0.7	0.25	0.0625
Fines Mill	4.5 (1)	1.935	1.26	0.45	0.1125
Screening	0.2 (6)	0.086	0.056	0.02	0.005

Corrections ② for high moisture, e.g., $\geq 4\%$

<u>Activity</u>	<u>Correction</u>
Primary Crush	Factor X .04
Secondary	Factor X .02
All other process	Factor X .15

① Used particle size distribution provided in Metallic Minerals Processing Section V for TSP and <10 um and extrapolated to get remaining sizes by using the average of the coal mining size distributions (Appendix A). The reason for this was that the relationship of the TSP to <10 um for low moisture ore was closer than that for the other activities.

② Derived from values given in Section V.

8.23 METALLIC MINERALS PROCESSING

8.23.1 Process Description¹⁻⁶

Metallic mineral processing typically involves the mining of ore, either from open pit or underground mines; the crushing and grinding of ore; the separation of valuable minerals from matrix rock through various concentration steps; and at some operations, the drying, calcining or pelletizing of concentrates to ease further handling and refining. Figure 8.23-1 is a general flow diagram for metallic mineral processing. Very few metallic mineral processing facilities will contain all of the operations depicted in this Figure, but all facilities will use at least some of these operations in the process of separating valued minerals from the matrix rock.

The number of crushing steps necessary to reduce ore to the proper size will vary with the type of ore. Hard ores, including some copper, gold, iron and molybdenum ores, may require as much as a tertiary crushing. Softer ores, such as some uranium, bauxite and titanium/zirconium ores, require little or no crushing. Final comminution of both hard and soft ores is often accomplished by grinding operations using media such as balls or rods of various materials. Grinding is most often performed with an ore/water slurry, which reduces particulate emissions to negligible levels. When dry grinding processes are used, particulate emissions can be considerable.

After final size reduction, the beneficiation of the ore increases the concentration of valuable minerals by separating them from the matrix rock. A variety of physical and chemical processes is used to concentrate the mineral. Most often, physical or chemical separation is performed in an aqueous environment which eliminates particulate emissions, although some ferrous and titaniferous minerals are separated by magnetic or electrostatic methods in a dry environment.

The concentrated mineral products may be dried to remove surface moisture. Drying is most frequently done in natural gas fired rotary dryers. Calcining or pelletizing of some products, such as alumina or iron concentrates, are also performed. Emissions from calcining and pelletizing operations are not covered in this Section.

8.23.2 Process Emissions⁷⁻⁹

Particulate emissions result from metallic mineral plant operations such as crushing and dry grinding of ore; drying of concentrates; storing and reclaiming of ores and concentrates from storage bins; transfer of materials; and loading of final products for shipment. Particulate emission factors are provided in Table 8.23-1 for various metallic mineral process operations, including primary, secondary and tertiary crushing; dry grinding; drying; and material handling and transfer. Fugitive emissions are also possible from roads and open stockpiles, factors for which are in Section 11.2.

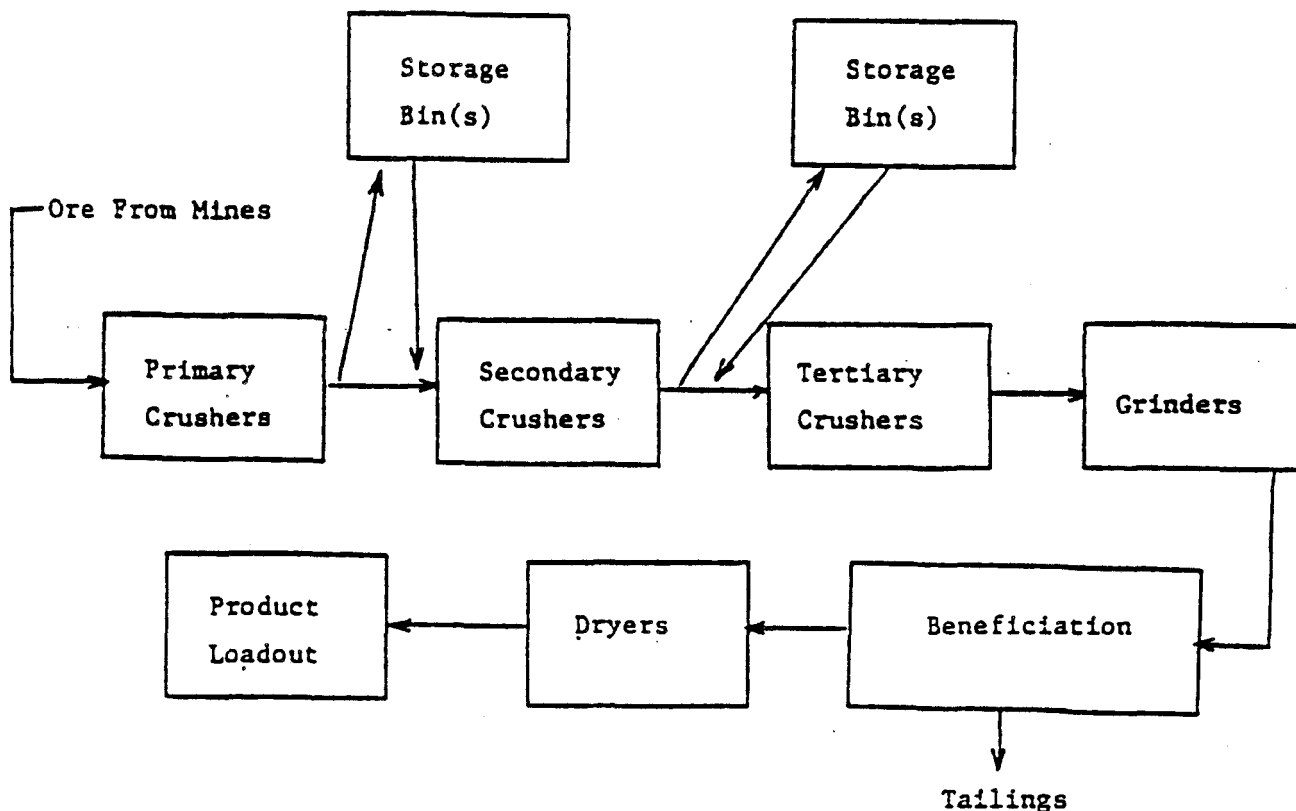


Figure 8.23-1. A metallic mineral processing plant.

The emission factors in Table 8.23-1 are for the process operations as a whole. At most metallic mineral processing plants, each process operation will require several types of equipment. A single crushing operation likely will include a hopper or ore dump, screen(s), crusher, surge bin, apron feeder, and conveyor belt transfer points. Emissions from these various pieces of equipment are often ducted to a single control device. The emission factors provided in Table 8.23-1 for primary, secondary and tertiary crushing operations are for process units that are typical arrangements of the above equipment.

Emission factors are provided in Table 8.23-1 for two types of dry grinding operations, those grinding operations that involve air conveying and/or air classification of material and those that involve screening of material without air conveying. Grinding operations that involve air conveying and air classification usually require dry cyclones for efficient product recovery. The factors in Table 8.23-1 are for emissions after product recovery cyclones. Grinders in closed circuit with screens usually do not require cyclones. Emission factors are not provided for wet grinders, because the high moisture content in these operations can reduce emissions to negligible levels.

The emission factors for dryers in Table 8.23-1 include transfer points integral with the drying operation. A separate emission factor is provided for dryers at titanium/zirconium plants that use dry cyclones for product recovery and for emission control. Titanium/zirconium sand type ores do not require crushing or grinding, and the ore is washed to remove humic and clay material before concentration and drying operations.

At some metallic mineral processing plants, material is stored in enclosed bins between process operations. The emission factors provided in Table 8.23-1 for the handling and transfer of material should be applied to the loading of material into storage bins and the transferring of material from the bin. The emission factor will usually be applied twice to a storage operation, once for the loading operation and once for the reclaiming operation. If material is stored at multiple points in the plant, the emission factor should be applied to each operation and should apply to the material being stored at each bin. The material handling and transfer factors do not apply to small hoppers, surge bins or transfer points that are integral with crushing, drying or grinding operations.

At some large metallic mineral processing plants, extensive material transfer operations, with numerous conveyor belt transfer points, may be required. The emission factors for material handling and transfer should be applied to each transfer point that is not an integral part of another process unit. These emission factors should be applied to each such conveyor transfer point and should be based on the amount of material transferred through that point.

The emission factors for material handling can also be applied to final product loading for shipment. Again, these factors should be applied to each transfer point, ore dump or other point where material is allowed to fall freely.

Test data collected in the mineral processing industries indicate that the moisture content of ore can have a significant effect on emissions from several process operations. High moisture generally reduces the uncontrolled emission rates, and separate emission rates are provided for primary crushers, secondary crushers, tertiary crushers, and material handling and transfer operations that process high moisture ore. Drying and dry grinding operations are assumed to produce or to involve only low moisture material.

For most metallic minerals covered in this Section, high moisture ore is defined as ore whose moisture content, as measured at the primary crusher inlet or at the mine, is 4 weight percent or greater. Ore defined as high moisture at the primary crusher is presumed to be high moisture ore at any subsequent operation for which high moisture factors are provided, unless a drying operation precedes the operation under consideration. Ore is defined as low moisture when a dryer precedes the operation under consideration or when the ore moisture at the mine or primary crusher is less than 4 weight percent.

Separate factors are provided for bauxite handling operations, in that some types of bauxite with a moisture content as high as 15 to 18 weight percent can still produce relatively high emissions during material handling

TABLE 8.23-1. UNCONTROLLED PARTICULATE EMISSION FACTORS FOR METALLIC MINERAL PROCESSES^a

Process	Low moisture ore ^b		High moisture ore ^b		Emission Factor Rating
	Emissions kg/Hg (lb/ton)	Particulate emissions < 10 μ m kg/Hg (lb/ton)	Emissions kg/Hg (lb/ton)	Particulate emissions < 10 μ m kg/Hg (lb/ton)	
Crushing ^c					
Primary	0.2 (0.5)	0.02 (0.05)	0.01 (0.02)	0.004 (0.009)	C
Secondary	0.6 (1.2)	NA	0.03 (0.05)	0.012 (0.02)	D
Tertiary	1.4 (2.7)	0.08 (0.16)	0.03 (0.06)	0.001 (0.02)	E
Wet grinding	Negligible	-	Negligible	-	
Dry grinding ^d					
With air conveying and/or air classification	14.4 (28.8)	13.0 (26.0)	d	d	C
Without air conveying or air classification	1.2 (2.4)	0.16 (0.31)	d	d	D
Drying ^e					
All minerals but titanium/zirconium sands	9.8 (19.7)	5.9 (12.0)	e	e	C
Titanium/zirconium with cyclones	0.3 (0.5)	NA	e	e	C
Material handling and transfer ^f					
All minerals but bauxite	0.06 (0.12)	0.03 (0.06)	0.005 (0.01)	0.002 (0.006)	C
Bauxite/alumina	0.6 (1.1)	NA	NA	NA	C

^aReferences 9-12. Controlled particulate emission factors are discussed in Section 8.23.3. NA = not available.^bDefined in Section 8.23.2.^cBased on weight of material entering primary crusher.^dBased on weight of material entering grinder. Factors are the same for both high moisture and low moisture ores, because material is usually dried before entering grinder.^eBased on weight of material exiting dryer. Factors are the same for both high moisture and low moisture ores. SO_x emissions are fuel dependent (see Chapter 1). NO_x emissions depend on burner design, combustion temperature, etc. (see Chapter 1).^fBased on weight of material transferred. Applies to each loading or unloading operation and to each conveyor belt transfer point.^gBauxite with moisture content as high as 15 - 18% can exhibit the emission characteristics of low moisture ore. Use low moisture factor for bauxite unless material exhibits obvious sticky, nondusting characteristics.

procedures. These emissions could be eliminated by adding sufficient moisture to the ore, but bauxite then becomes so sticky that it is difficult to handle. Thus, there is some advantage to keeping bauxite in a relatively dusty state, and the low moisture emission factors given represent conditions fairly typical of the industry.

Particulate matter size distribution data for some process operations have been obtained for control device inlet streams. Since these inlet streams contain particulate matter from several activities, a variability has been anticipated in the calculated size specific emission factors for particulates.

Emission factors for particulate matter equal to or less than 10 μ m aerodynamic diameter, from a limited number of tests performed to characterize the processes, are presented in Table 8.23-1.

In some plants, particulate emissions from multiple pieces of equipment and operations are collected and ducted to a control device. Therefore, examination of reference documents is recommended before application of the factors to specific plants.

Emission factors for particulate matter equal to or less than 10 μ m from high moisture primary crushing operations and material handling and transfer operations were based on test results usually in the 30 to 40 weight percent range. However, high values were obtained for high moisture ore at both the primary crushing and the material handling and transfer operations, and these were included in the average values in the Table. A similarly wide range occurred in the low moisture drying operation.

Several other factors are generally assumed to affect the level of emissions from a particular process operation. These include ore characteristics such as hardness, crystal and grain structure, and friability. Equipment design characteristics, such as crusher type, could also affect the emissions level. At this time, data are not sufficient to quantify each of these variables.

8.23.3 Controlled Emissions⁷⁻⁹

Emissions from metallic mineral processing plants are usually controlled with wet scrubbers or baghouses. For moderate to heavy uncontrolled emission rates from typical dry ore operations, dryers and dry grinders, a wet scrubber with pressure drop of 1.5 to 2.5 kilopascals (6 to 10 inches of water) will reduce emissions by approximately 95 percent. With very low uncontrolled emission rates typical of high moisture conditions, the percentage reduction will be lower (approximately 70 percent).

Over a wide range of inlet mass loadings, a well designed and maintained baghouse will reduce emissions to a relatively constant outlet concentration. Such baghouses tested in the mineral processing industry consistently reduce emissions to less than 0.05 grams per dry standard cubic meter (0.02 grains per dry standard cubic foot), with an average concentration of 0.015 g/dscm (0.006 gr/dscf). Under conditions of moderate to high uncontrolled emission rates of typical dry ore facilities, this level of

controlled emissions represents greater than 99 percent removal of particulate emissions. Because baghouses reduce emissions to a relatively constant outlet concentration, percentage emission reductions would be less for baghouses on facilities with a low level of uncontrolled emissions.

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11.2.1 UNPAVED ROADS

11.2.1.1 General

Dust plumes trailing behind vehicles traveling on unpaved roads are a familiar sight in rural areas of the United States. When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

11.2.1.2 Emissions and Correction Parameters

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. Also, field investigations have shown that emissions depend on correction parameters (average vehicle speed, average vehicle weight, average number of wheels per vehicle, road surface texture and road surface moisture) that characterize the condition of a particular road and the associated vehicle traffic.¹⁻⁴

Dust emissions from unpaved roads have been found to vary in direct proportion to the fraction of silt (particles smaller than 75 micrometers in diameter) in the road surface material.¹ The silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200 mesh screen, using the ASTM-C-136 method. Table 11.2.1-1 summarizes measured silt values for industrial and rural unpaved roads.

TABLE 11.2.1-1. TYPICAL SILT CONTENT VALUES OF SURFACE MATERIALS ON INDUSTRIAL AND RURAL UNPAVED ROADS^a

Industry	Road use or surface material	No. of test samples	Silt (%)	
			Range	Mean
Iron and steel production	Plant road	13	4.3 - 13	7.3
Taconite mining and processing	Haul road	12	3.7 - 9.7	5.8
	Service road	8	2.4 - 7.1	4.3
Western surface coal mining	Access road	2	4.9 - 5.3	5.1
	Haul road	21	2.8 - 18	8.4
	Scraper road	10	7.2 - 25	17
	Haul road (freshly graded)	5	18 - 29	24
Rural roads	Gravel	2	12 - 13	12
	Dirt	1		68

^a References 1-9.

5/83

Miscellaneous Sources

11.2.1-1

The silt content of a rural dirt road will vary with location, and it should be measured. As a conservative approximation, the silt content of the parent soil in the area can be used. However, tests show that road silt content is normally lower than the surrounding parent soil, because the fines are continually removed by the vehicle traffic, leaving a higher percentage of coarse particles.

Unpaved roads have a hard nonporous surface that usually dries quickly after a rainfall. The temporary reduction in emissions because of precipitation may be accounted for by neglecting emissions on "wet" days [more than 0.254 mm (0.01 in.) of precipitation].

11.2.1.3 Predictive Emission Factor Equations

The following empirical expression may be used to estimate the quantity of size specific particulate emissions from an unpaved road, per vehicle unit of travel, with a rating of A:

$$E = k(1.7) \left(\frac{s}{12}\right) \left(\frac{S}{48}\right) \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{w}{4}\right)^{0.5} \left(\frac{365-p}{365}\right) \text{ (kg/VKT)} \quad (1)$$

$$E = k(5.9) \left(\frac{s}{12}\right) \left(\frac{S}{30}\right) \left(\frac{W}{3}\right)^{0.7} \left(\frac{w}{4}\right)^{0.5} \left(\frac{365-p}{365}\right) \text{ (lb/VMT)}$$

where: E = emission factor

k = particle size multiplier (dimensionless)

s = silt content of road surface material (%)

S = mean vehicle speed, km/hr (mph)

W = mean vehicle weight, Mg (tons)

w = mean number of wheels

p = number of days with at least 0.254 mm (0.01 in.) of precipitation per year

The particle size multiplier (k) in Equation 1 varies with aerodynamic particle size range as follows:

Aerodynamic Particle Size Multiplier
for Equation 1

< 30 μm	< 15 μm	< 10 μm	< 5 μm	< 2.5 μm
0.80	0.57	0.45	0.28	0.16

The number of wet days per year (p) for the geographical area of interest should be determined from local climatic data. Figure 11.2.1-1 gives the geographical distribution of the mean annual number of wet days per year in the United States.

Equation 1 retains the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equation, as follows:

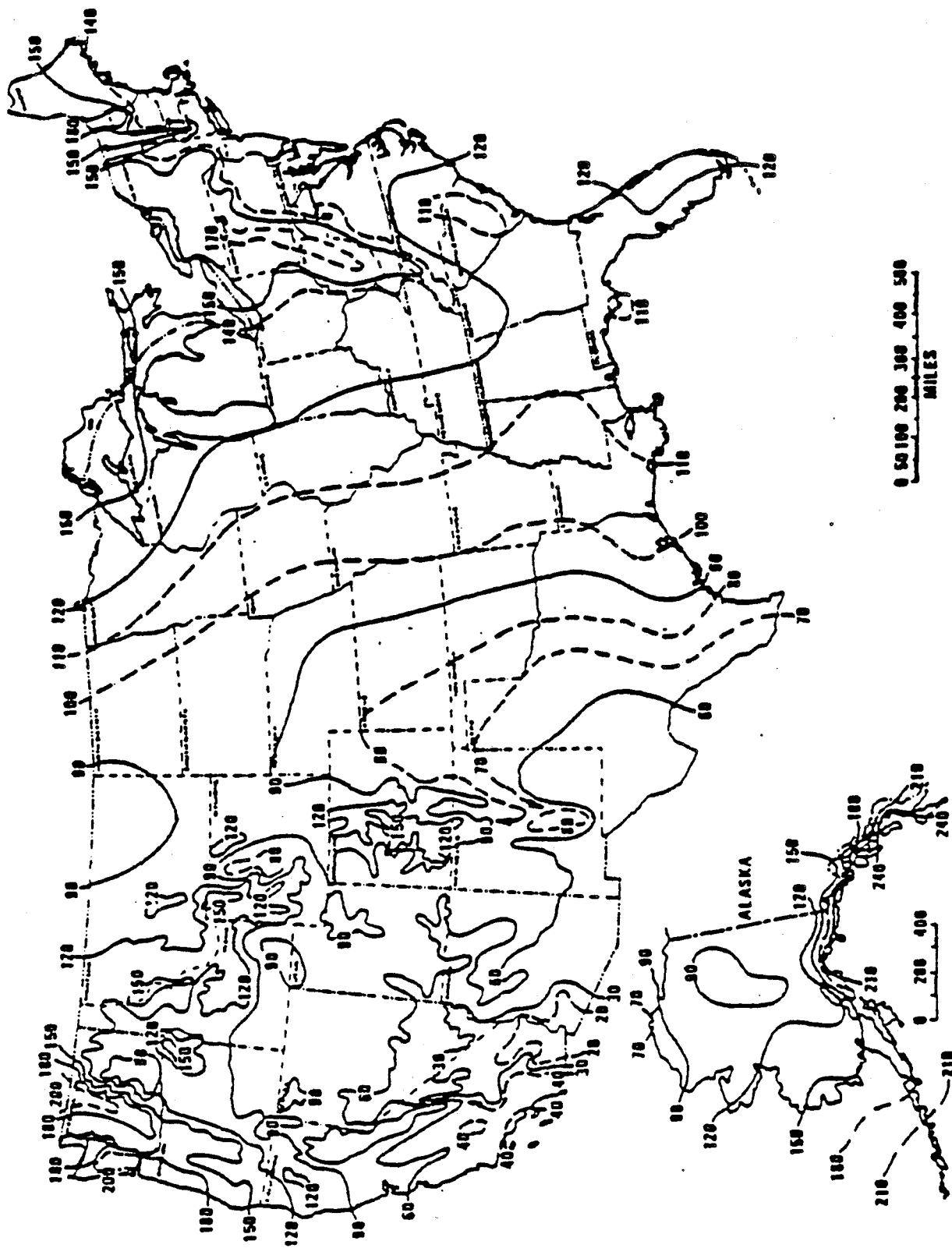


Figure 11.2.1-1. Mean number of days with 0.01 inch or more of precipitation in United States. 10

Range of Source Conditions for Equation 1

Road surface silt content (%)	Mean vehicle weight		Mean vehicle speed		Mean No. of wheels
	Mg	tons	km/hr	mph	
4.3 - 20	2.7 - 142	3 - 157	21 - 64	13 - 40	4 - 13

Also, to retain the quality rating of Equation 1 applied to a specific unpaved road, it is necessary that reliable correction parameter values for the specific road in question be determined. The field and laboratory procedures for determining road surface silt content are given in Reference 4. In the event that site specific values for correction parameters cannot be obtained, the appropriate mean values from Table 11.2.1-1 may be used, but the quality rating of the equation is reduced to B.

Equation 1 was developed for calculation of annual average emissions, and thus, is to be multiplied by annual source extent in vehicle distance traveled (VDT). Annual average values for each of the correction parameters are to be substituted into the equation. Worst case emissions, corresponding to dry road conditions, may be calculated by setting $p = 0$ in Equation 1 (which is equivalent to dropping the last term from the equation). A separate set of nonclimatic correction parameters and a higher than normal VDT value may also be justified for the worst case averaging period (usually 24 hours). Similarly, to calculate emissions for a 91 day season of the year using Equation 1, replace the term $(365-p)/365$ with the term $(91-p)/91$, and set p equal to the number of wet days in the 91 day period. Also, use appropriate seasonal values for the nonclimatic correction parameters and for VDT.

11.2.1.4 Control Methods

Common control techniques for unpaved roads are paving, surface treating with penetration chemicals, working soil stabilization chemicals into the roadbed, watering, and traffic control regulations. Paving, as a control technique, is often not economically practical. Surface chemical treatment and watering can be accomplished with moderate to low costs, but frequent retreatments are required. Traffic controls such as speed limits and traffic volume restrictions provide moderate emission reductions but may be difficult to enforce. Table 11.2.1-3 shows approximate control efficiencies achievable for each method. Watering, because of the frequency of treatments required, is generally not feasible for public roads and is effectively used only where water and watering equipment are available and where roads are confined to a single site, such as a construction location.

TABLE 11.2.1-3. CONTROL METHODS FOR UNPAVED ROADS¹¹

Control method	Approximate control efficiency (%)
Paving	85
Treating surface with penetrating chemicals	50
Working soil stabilizing chemicals into roadbed	50
Speed control ^a	
48 kph (30 mph)	25
32 kph (20 mph)	50
24 kph (15 mph)	63

^a Based on the assumption that "uncontrolled" speed is typically 64 kph (40 mph). Between 21 and 64 kph (13 and 40 mph), emissions are linearly proportional to vehicle speed (see Equation 1).

References for Section 11.2.1

1. C. Cowherd, et al., Development of Emission Factors for Fugitive Dust Sources, EPA-450/3-74-037, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.
2. R. J. Dyck and J. J. Stukel, "Fugitive Dust Emissions from Trucks on Unpaved Roads", Environmental Science and Technology, 10(10):1046-1048, October 1976.
3. R. O. McCaldin and K. J. Heidel, "Particulate Emissions from Vehicle Travel over Unpaved Roads", Presented at the 71st Annual Meeting of the Air Pollution Control Association, Houston, TX, June 1978.
4. C. Cowherd, Jr., et al., Iron and Steel Plant Open Dust Source Fugitive Emission Evaluation, EPA-600/2-79-103, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1979.
5. R. Bohn, et al., Fugitive Emissions from Integrated Iron and Steel Plants, EPA-600/2-78-050, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1978.
6. R. Bohn, Evaluation of Open Dust Sources in the Vicinity of Buffalo, New York, U. S. Environmental Protection Agency, New York, NY, March 1979.

7. C. Cowherd, Jr., and T. Cuscino, Jr., Fugitive Emissions Evaluation, Equitable Environmental Health, Inc., Elmhurst, IL, February 1977.
8. T. Cuscino, et al., Taconite Mining Fugitive Emissions Study, Minnesota Pollution Control Agency, Roseville, MN, June 1979.
9. K. Axetell and C. Cowherd, Jr., Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources, 2 Volumes, EPA Contract No. 68-03-2924, PEDCo Environmental, Inc., Kansas City, MO, July 1981.
10. Climatic Atlas of the United States, U. S. Department of Commerce, Washington, DC, June 1968.
11. G. A. Jutze, et al., Investigation of Fugitive Dust Sources Emissions and Control, EPA-450/3-74-036a, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

11.2.6 INDUSTRIAL PAVED ROADS

11.2.6.1 General

Various field studies have indicated that dust emissions from industrial paved roads are a major component of atmospheric particulate matter in the vicinity of industrial operations. Industrial traffic dust has been found to consist primarily of mineral matter, mostly tracked or deposited onto the roadway by vehicle traffic itself when vehicles enter from an unpaved area or travel on the shoulder of the road, or when material is spilled onto the paved surface from haul truck traffic.

11.2.6.2 Emissions and Correction Parameters

The quantity of dust emissions from a given segment of paved road varies linearly with the volume of traffic. In addition, field investigations have shown that emissions depend on correction parameters (road surface silt content, surface dust loading and average vehicle weight) of a particular road and associated vehicle traffic.¹⁻²

Dust emissions from industrial paved roads have been found to vary in direct proportion to the fraction of silt (particles < 75 μ m in diameter) in the road surface material.¹⁻² The silt fraction is determined by measuring the proportion of loose dry surface dust that passes a 200 mesh screen, using the ASTM-C-136 method. In addition, it has also been found that emissions vary in direct proportion to the surface dust loading.¹⁻² The road surface dust loading is that loose material which can be collected by vacuuming and broom sweeping the traveled portion of the paved road. Table 11.2.6-1 summarizes measured silt and loading values for industrial paved roads.

TABLE 11.2.6-1. TYPICAL SILT CONTENT AND LOADING VALUES FOR PAVED ROADS AT IRON AND STEEL PLANTS^a

Industry	Travel lanes	Silt (%)		Loading			
		Range	Mean	Range		Mean	
				kg/km	lb/mi	kg/km	lb/mi
Iron and steel production	2	1.1 - 13	5.9	18 - 4,800	65 - 17,000	760	2,700

^a References 1-3. Based on nine test samples.

11.2.6.3 Predictive Emission Factor Equation

The quantity of particulate emissions generated by vehicle traffic on dry industrial paved roads, per vehicle mile traveled, may be estimated, with a rating of B or D (see below), using the following empirical expression:

$$E = k(0.025)I \left(\frac{4}{n}\right) \left(\frac{s}{10}\right) \left(\frac{L}{280}\right) \left(\frac{W}{2.7}\right)^{0.7} \quad (\text{kg/VKT}) \quad (1)$$

$$E = k(0.090)I \left(\frac{4}{n}\right) \left(\frac{s}{10}\right) \left(\frac{L}{1,000}\right) \left(\frac{W}{3}\right)^{0.7} \quad (\text{lb/VMT})$$

where: E = emission factor
 k = particle size multiplier (dimensionless) (see below)
 I = industrial augmentation factor (dimensionless) (see below)
 n = number of traffic lanes
 s = surface material silt content (%)
 L = surface dust loading, kg/km (lb/mile) (see below)
 W = average vehicle weight, Mg (tons)

The particle size multiplier (k) above varies with aerodynamic size range as follows:

Aerodynamic Particle Size Multiplier (k)
for Equation 1

< 30 μm	< 15 μm	< 10 μm	< 5 μm	< 2.5 μm
0.86	0.64	0.51	0.32	0.17

To determine particulate emissions for a specific particle size range, use the appropriate value of k shown above.

The industrial road augmentation factor (I) in the equation takes into account higher emissions from industrial roads than from urban roads. I = 7.0 for an industrial roadway which traffic enters from unpaved areas. I = 3.5 for an industrial roadway with unpaved shoulders. I = 1.0 for cases in which traffic does not travel unpaved areas. A value of I between 1.0 and 7.0 should be used in the equation which best represents conditions for paved roads at a certain industrial facility.

The equation retains the quality rating of B if applied to vehicles traveling entirely on paved surfaces (I = 1.0) and if applied within the range of source conditions that were tested in developing the equation as follows:

Silt content (%)	Surface loading		No. of lanes	Vehicle weight	
	kg/km	lb/mile		Mg	tons
5.1 - 92	42.0 - 2,000	149 - 7,100	2 - 4	2.7 - 12	3 - 13

If $I > 1.0$, the rating of the equation drops to D because of the arbitrariness in the guidelines for estimating I.

Also, to retain the quality ratings of Equation 1 applied to a specific industrial paved road, it is necessary that reliable correction parameter values for the specific road in question be determined. The field and laboratory procedures for determining surface material silt content and surface dust loading are given in Reference 2. In the event that site specific values for correction parameters cannot be obtained, the appropriate mean values from Table 11.2.6-1 may be used, but the quality ratings of the equation are reduced by one level.

References for Section 11.2.6

1. R. Bohn, et al., Fugitive Emissions from Integrated Iron and Steel Plants, EPA-600/2-78-050, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1978.
2. C. Cowherd, Jr., et al., Iron and Steel Plant Open Dust Source Fugitive Emission Evaluation, EPA-600/2-79-103, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1979.
3. R. Bohn, Evaluation of Open Dust Sources in the Vicinity of Buffalo, New York, U. S. Environmental Protection Agency, New York, NY, March 1979.

11.2.3 AGGREGATE HANDLING AND STORAGE PILES

11.2.3.1 General

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage.

Dust emissions occur at several points in the storage cycle, during material loading onto the pile, during disturbances by strong wind currents, and during loadout from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

11.2.3.2 Emissions and Correction Parameters

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Also, emissions depend on three correction parameters that characterize the condition of a particular storage pile: age of the pile, moisture content and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, its potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents from aggregate transfer itself or high winds. As the aggregate weathers, however, potential for dust emissions is greatly reduced. Moisture causes agglomeration and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile, and the drying process is very slow.

Field investigations have shown that emissions from aggregate storage operations vary in direct proportion to the percentage of silt (particles < 75 μm in diameter) in the aggregate material.^{1 3} The silt content is determined by measuring the proportion of dry aggregate material that passes through a 200 mesh screen, using ASTM-C-136 method. Table 11.2.3-1 summarizes measured silt and moisture values for industrial aggregate materials.

11.2.3.3 Predictive Emission Factor Equations

Total dust emissions from aggregate storage piles are contributions of several distinct source activities within the storage cycle:

1. Loading of aggregate onto storage piles (batch or continuous drop operations).
2. Equipment traffic in storage area:
3. Wind erosion of pile surfaces and ground areas around piles.
4. Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

TABLE 11.2.3-1. TYPICAL SILT AND MOISTURE CONTENT VALUES
OF MATERIALS AT VARIOUS INDUSTRIES

Industry	Material	Silt (%)			Moisture (%)		
		No. of test samples	Range	Mean	No. of test samples	Range	Mean
Iron and steel production	Pellet ore	10	1.4 - 13	4.9	8	0.64 - 3.5	2.1
	Lump ore	9	2.8 - 19	9.5	6	1.6 - 8.1	5.4
	Coal	7	2 - 7.7	5	6	2.8 - 11	4.8
	Slag	3	3 - 7.3	5.3	3	0.25 - 2.2	0.92
	Flue dust	2	14 - 23	18.0	0	NA	NA
	Coke breeze	1		5.4	1		6.4
	Blended ore	1		15.0	1		6.6
	Sinter	1		0.7	0	NA	NA
	Limestone	1		0.4	0	NA	NA
Stone quarrying ^b and processing ^c	Crushed limestone	2	1.3 - 1.9	1.6	2	0.3 - 1.1	0.7
Taconite mining ^c and processing ^c	Pellets	9	2.2 - 5.4	3.4	7	0.05 - 2.3	0.96
	Tailings	2	NA	11.0	1		0.35
Western surface coal mining ^d	Coal	15	3.4 - 16	6.2	7	2.8 - 20	6.9
	Overburden	15	3.8 - 15	7.5	0	NA	NA
	Exposed ground	3	5.1 - 21	15.0	3	0.8 - 6.4	3.4

^a References 2-5. NA = not applicable.

^b Reference 1.

^c Reference 6.

^d Reference 7.

Adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

The quantity of particulate emissions generated by a batch drop operation, per ton of material transferred, may be estimated, with a rating of C, using the following empirical expression²:

$$E = k(0.00090) \frac{\left(\frac{s}{5}\right) \left(\frac{U}{2.2}\right) \left(\frac{H}{1.5}\right)}{\left(\frac{M}{2}\right)^2 \left(\frac{Y}{4.6}\right)^{0.33}} \quad (\text{kg/Mg}) \quad (1)$$

$$E = k(0.0018) \frac{\left(\frac{s}{5}\right) \left(\frac{U}{5}\right) \left(\frac{H}{5}\right)}{\left(\frac{M}{2}\right)^2 \left(\frac{Y}{6}\right)^{0.33}} \quad (\text{lb/ton})$$

where: E = emission factor
k = particle size multiplier (dimensionless)
s = material silt content (%)
U = mean wind speed, m/s (mph)
H = drop height, m (ft)
M = material moisture content (%)
Y = dumping device capacity, m³ (yd³)

The particle size multiplier (k) for Equation 1 varies with aerodynamic particle size, shown in Table 11.2.3-2.

TABLE 11.2.3-2. AERODYNAMIC PARTICLE SIZE
MULTIPLIER (k) FOR
EQUATIONS 1 AND 2

Equation	< 30 μm	< 15 μm	< 10 μm	< 5 μm	< 2.5 μm
Batch drop	0.73	0.48	0.36	0.23	0.13
Continuous drop	0.77	0.49	0.37	0.21	0.11

The quantity of particulate emissions generated by a continuous drop operation, per ton of material transferred, may be estimated, with a rating of C, using the following empirical expression³:

$$E = k(0.00090) \frac{\left(\frac{s}{5}\right) \left(\frac{U}{2.2}\right) \left(\frac{H}{3.0}\right)}{\left(\frac{M}{2}\right)^2} \quad (\text{kg/Mg}) \quad (2)$$

$$E = k(0.0018) \frac{\left(\frac{s}{5}\right) \left(\frac{U}{5}\right) \left(\frac{H}{10}\right)}{\left(\frac{M}{2}\right)^2} \quad (\text{lb/ton})$$

where: E = emission factor
 k = particle size multiplier (dimensionless)
 s = material silt content (%)
 U = mean wind speed, m/s (mph)
 H = drop height, m (ft)
 M = material moisture content (%)

The particle size multiplier (k) for Equation 2 varies with aerodynamic particle size, as shown in Table 11.2.3-2.

Equations 1 and 2 retain the assigned quality rating if applied within the ranges of source conditions that were tested in developing the equations, as given in Table 11.2.3-3. Also, to retain the quality ratings of Equations 1 or 2 applied to a specific facility, it is necessary that reliable correction parameters be determined for the specific sources of interest. The field and laboratory procedures for aggregate sampling are given in Reference 3. In the event that site specific values for correction parameters cannot be obtained, the appropriate mean values from Table 11.2.3-1 may be used, but in that case, the quality ratings of the equations are reduced by one level.

TABLE 11.2.3-3. RANGES OF SOURCE CONDITIONS FOR EQUATIONS 1 AND 2^a

Equation	Silt content (%)	Moisture content (%)	Dumping capacity		Drop height	
			m ³	yd ³	m	ft
Batch drop	1.3 - 7.3	0.25 - 0.70	2.10 - 7.6	2.75 - 10	NA	NA
Continuous drop	1.4 - 19	0.64 - 4.8	NA	NA	1.5 - 12	4.8 - 39

^a NA = not applicable.

For emissions from equipment traffic (trucks, front end loaders, dozers, etc.) traveling between or on piles, it is recommended that the equations for vehicle traffic on unpaved surfaces be used (see Section 11.2.1). For vehicle travel between storage piles, the silt value(s) for the areas

among the piles (which may differ from the silt values for the stored materials) should be used.

For emissions from wind erosion of active storage piles, the following total suspended particulate (TSP) emission factor equation is recommended:

$$E = 1.9 \left(\frac{s}{1.5} \right) \left(\frac{365-p}{235} \right) \left(\frac{f}{15} \right) \text{ (kg/day/hectare)} \quad (3)$$

$$E = 1.7 \left(\frac{s}{1.5} \right) \left(\frac{365-p}{235} \right) \left(\frac{f}{15} \right) \text{ (lb/day/acre)}$$

where: E = total suspended particulate emission factor
s = silt content of aggregate (%)
p = number of days with ≥ 0.25 mm (0.01 in.) of precipitation per year
f = percentage of time that the unobstructed wind speed exceeds 5.4 m/s (12 mph) at the mean pile height

The coefficient in Equation 3 is taken from Reference 1, based on sampling of emissions from a sand and gravel storage pile area during periods when transfer and maintenance equipment was not operating. The factor from Test Report 1, expressed in mass per unit area per day, is more reliable than the factor expressed in mass per unit mass of material placed in storage, for reasons stated in that report. Note that the coefficient has been halved to adjust for the estimate that the wind speed through the emission layer at the test site was one half of the value measured above the top of the piles. The other terms in this equation were added to correct for silt, precipitation and frequency of high winds, as discussed in Reference 2. Equation 3 is rated C for application in the sand and gravel industry and D for other industries.

Worst case emissions from storage pile areas occur under dry windy conditions. Worst case emissions from materials handling (batch and continuous drop) operations may be calculated by substituting into Equations 1 and 2 appropriate values for aggregate material moisture content and for anticipated wind speeds during the worst case averaging period, usually 24 hours. The treatment of dry conditions for vehicle traffic (Section 11.2.1) and for wind erosion (Equation 3), centering around parameter p, follows the methodology described in Section 11.2.1. Also, a separate set of nonclimatic correction parameters and source extent values corresponding to higher than normal storage pile activity may be justified for the worst case averaging period.

11.2.3.4 Control Methods

Watering and chemical wetting agents are the principal means for control of aggregate storage pile emissions. Enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering is useful mainly to reduce emissions from vehicle traffic in the storage pile area. Watering of the storage piles themselves typically has only a very temporary slight effect on total emissions. A much more effective technique is to apply chemical wetting agents for better wetting of fines and

longer retention of the moisture film. Continuous chemical treatment of material loaded onto piles, coupled with watering or treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent.⁸

References for Section 11.2.3

1. C. Cowherd, Jr., et al., Development of Emission Factors for Fugitive Dust Sources, EPA-450/3-74-037a, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.
2. R. Bohn, et al., Fugitive Emissions from Integrated Iron and Steel Plants, EPA-600/2-78-050, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1978.
3. C. Cowherd, Jr., et al., Iron and Steel Plant Open Dust Source Fugitive Emission Evaluation, EPA-600/2-79-103, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1979.
4. R. Bohn, Evaluation of Open Dust Sources in the Vicinity of Buffalo, New York, U. S. Environmental Protection Agency, New York, NY, March 1979.
5. C. Cowherd, Jr., and T. Cuscino, Jr., Fugitive Emissions Evaluation, Equitable Environmental Health, Inc., Elmhurst, IL, February 1977.
6. T. Cuscino, et al., Taconite Mining Fugitive Emissions Study, Minnesota Pollution Control Agency, Roseville, MN, June 1979.
7. K. Axetell and C. Cowherd, Jr., Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources, 2 Volumes, EPA Contract No. 68-03-2924, PEDCo Environmental, Inc., Kansas City, MO, July 1981.
8. G. A. Jutze, et al., Investigation of Fugitive Dust Sources Emissions and Control, EPA-450/3-74-036a, U. S. Environmental Protection Agency, Research Triangle Park, NC, June 1974.

SECTION VIII

AGGREGATE HANDLING AND STORAGE PILES

When determining particle size distribution for storage pile emissions use the same multipliers or proportions given for batch drop in this section.

For purposes of estimating average pile sizes we will use a capacity factor of 2 for coal and 6 for soil or sand/gravel and disregard pile configuration. (See September 30, 1981 Compilation of Emission Factors if clarification or more accurate size determinations are needed). Therefore, use the following numbers when estimating stockpile emissions:

<u>Weight of Material Stockpiled (tons)</u>	<u>Surface Area of Pile (Acres)</u>	
	<u>Coal</u>	<u>Soil or Sand/Gravel</u>
1,000	0.22	0.11
5,000	0.64	0.31
10,000	1.02	0.49
50,000	3.0	1.43
100,000	4.74	2.28
500,000	13.9	6.7
750,000	18.2	8.7
1,000,000	22.0	10.5

PARTICLE SIZE DISTRIBUTIONS

We recommend the following procedures and multipliers to calculate particle size distributions as needed. For example, where emission factors are given for <30 and <10 that do not correspond to the multiplier, and you need to determine <15, you will need to proportion as follows:

Given:	<30 = 10 lb/ton <10 = 1 lb/ton	<3.0 0.8	Multipliers	
			<15 0.57	<10 0.45

Using the given multipliers and the <30 value, total particulates should be equal to $\frac{10}{.8} = 12.5$ and therefore $<10 = 12.5 \times .45 = 5.6 \neq 1$

However <10 is a given factor and we must use. Therefore, to determine <15 calculate as follows:

$$\left(\frac{0.57-0.45}{0.8-0.45} \right) \times (10-1) + 1 = (34\%)(9) + 1 = 4.06 \text{ Whereas if you}$$

only used the multiplier for <15 the value would be $= 0.57 \times 12.5 = 7.1$

Use the following given multipliers:

Emission Factor	<30 um	<15 um	<10 um	<5 um	<2.5 um
Batch Drop	.73	.48	.36	.23	.13
Continuous Drop	.77	.49	.37	.23	.11
Unpaved Road	.80	.57	.45	.28	.16
Paved Roads	.86	.64	.51	.32	.17
Averages	.79	.54	.42	.26	.14

In comparison we derived an "overall" particle size distribution for western surface coal mines by assigning a percentage of total mine emissions to each source considered significant, computed ratios for the given inhalable particulate and fine particulate to the total suspended particulate and plotted these numbers on lognormal graph paper to get:

<30	<15	<10	<5	<2.5
1.0	.43	.28	.10	.025

These multipliers are to be used as a guide only. Source and site specific data, if submitted, should be given priority.

CONTROL EFFICIENCIES

Activity	Methodology	Efficiency %	
Material Removal	None practical	N/A	
Material Placement	None practical	N/A	
Storage of materials/exposed areas (reduces annual emissions) (dependent on location & met. conditions)	Chemical suppressants	85	(6)
	Mulch	85	(6)
	Rapid Revegetation	75 (annual)	(6)
	Wind breaks=ht. of pile	50	(6)
	Wind breaks <ht of pile	30	(7)
	Adequate watering	50	(8)
	Water as needed	25	(5)
	Chemical/vegetative stabilization	93	(9)
	Portable screen fence	80	(10)
	Oiling	80	(7)
	Complete enclosure	99	(6)
	Partial enclosure	50	(5)
	Canvas covers	80	(7)
Drilling	Bag collector	90	(5)
	Chemical suppressants	90	(5 & 11)
	Water Injection	75	(5 & 11)
	Cyclone collector	75	(5)
Blasting	None practiced	N/A	
Loadouts	Negative pressure w/ fabric filter	85	(6)
	Chemical suppressants	85	(6)
	Enclosed structure	75	(5)
	Telescopic chute	75	(7)
	Stacker w/water spray	75	(7)
	Water spray	50	(8)
	Wind guard	50	(7)
	Stacker height adjustable	25	(7)
	Ladder	80	(7)
Transfer Points	Totally enclosed w/neg. pressure w/baghouse	99	(7)
	Totally enclosed w/water	99	(5)
	Totally enclosed	85	(5)
	Partially enclosed w/water	99	(5)
	Partially enclosed	70	(7)
	Chemical suppressants	85	(5)
	Water spray	70	(7)

Processing

Chemical suppressants	85	(6)
Water spray-multiple nozzles	75	(5)
Water spray	50	(8)
See Table A-2 for additional controls		

Unpaved Roads

See Section on Unpaved Roads		
Paving w/frequent sweep or flush	99	(5)
Paving w/infrequent clean- up	85	(5)
Soil stabilizer forming crust	80	(5)
Surface chemical treatment	75	(5)
Frequent watering	50	(12)
Water as needed	25	(5)
Gravel	50	(5)
Oiling	70	(5)

Table A-2. DISTRIBUTION BY PARTICLE SIZE OF AVERAGE COLLECTION EFFICIENCIES FOR VARIOUS PARTICULATE CONTROL EQUIPMENT^{a,b}

Type of collector	Efficiency, %					
	Particle size range, μm					
	Overall	0 to 5	5 to 10	10 to 20	20 to 44	>44
Baffled settling chamber	58.6	7.5	22	43	80	90
Simple cyclone	65.3	12	33	57	82	91
Long-cone cyclone	84.2	40	79	92	95	97
Multiple cyclone (12-in. diameter)	74.2	25	54	74	95	98
Multiple cyclone (6-in. diameter)	93.8	63	95	98	99.5	100
Irrigated long-cone cyclone	91.0	63	93	96	98.5	100
Electrostatic precipitator	97.0	72	94.5	97	99.5	100
Irrigated electrostatic precipitator	99.0	97	99	99.5	100	100
Spray tower	94.5	90	96	98	100	100
Self-induced spray scrubber	93.6	85	96	98	100	100
Disintegrator scrubber	98.5	93	98	99	100	100
Venturi scrubber	99.5	99	99.5	100	100	100
Wet-impingement scrubber	97.9	96	98.5	99	100	100
Baghouse	99.7	99.5	100	100	100	100

^aReferences 2 and 3.

^bData based on standard silica dust with the following particle size and weight distribution:

Particle size range, μm	Percent by weight
0 to 5	20
5 to 10	10
10 to 20	15
20 to 44	20
> 44	35

USEFUL WEIGHTS AND MEASURES (AVERAGES AND RANGES)

Cement	1 yd ³ = 2500 lb.
Concrete	1 yd ³ = 400 lb.
Coal (Bituminous)	1 ft ³ = 47-50 lb.
Coal (Bituminous)	1 yd ³ = .635 - .675 ton
Gravel, dry packed	1 ft ³ = 100-120 lb.
Gravel, wet	1 ft ³ = 126 lb.
Sand, gravel (dry, loose)	1 ft ³ = 90-105 lb.
Topsoil	1 ft ³ = 111 lb. (13)
Topsoil	1 yd ³ = 1.5 ton (13)
Overburden	1 yd ³ = 1.3 ton (4)
Uranium ore	1 yd ³ = 1.5 ton (14)
Rock (broken)	1 yd ³ = 1.35 ton (14)
Average depth of topsoil	1.5 ft. (15)
Average depth of overburden	120 ft. (as much as 3000 ft) (15)
Scraper capacity	25 yd ³ (5)
Dragline capacity	30-200 yd ³ (4)
Truck capacity	10-20 yd ³ (5) (as much as 200 ton)
Shovel capacity	5-8 yd ³ (16) (as much as 40 yd ³)
Frontend loader capacity	2.5-8 yd ³ (14) (as much as 20 yd ³)
Grizzly capacity	190-2000 tons/hour (14)
Rail car capacity	100 tons (5)
Conveyor capacity	53-1470 tons/hr. (14)

METEOROLOGICAL DATA

We may assume that on days where there is significant precipitation (>.01 inch), maximum temperatures below freezing, or a snow cover on the ground that emissions from some fugitive dust sources will be negligible. Therefore, the following table provides the average number of days per month that one of the above conditions may occur. The data is given for the five major weather stations in the State and may be applied to each major drainage area. (Figure D1)

Table D.1.

Precipitation >.01 inch (17)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alamosa	0	3	9	1	8	6	10	11	8	5	2	3	66
Grand Jct.	4	4	8	6	12	4	10	9	5	9	6	5	82
Pueblo	2	3	8	1	9	2	12 ²	13	5	5	2	3	65
Colo. Spgs.	3	5	10	5	17	10	18	19	7	5	1	5	105
Denver	2	4	10	4	16	9	7	8	6	7	3	6	82

Table D.2.

Days of minimal emissions due to freezing temps and/or snow cover (17)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Alamosa	1	1	1	0	0	0	0	0	0	0	0	9	12
Grand Jct.	0	1	0	0	0	0	0	0	0	0	0	6	7
Pueblo	0	2	0	0	0	0	0	0	0	0	0	4	6
Colo. Spgs.	1	2	2	0	0	0	0	0	0	0	1	8	14
Denver	1	6	7	0	0	0	0	0	0	0	3	8	25

Tables D.1. and D.2. may be used together for sources of wind erosion.

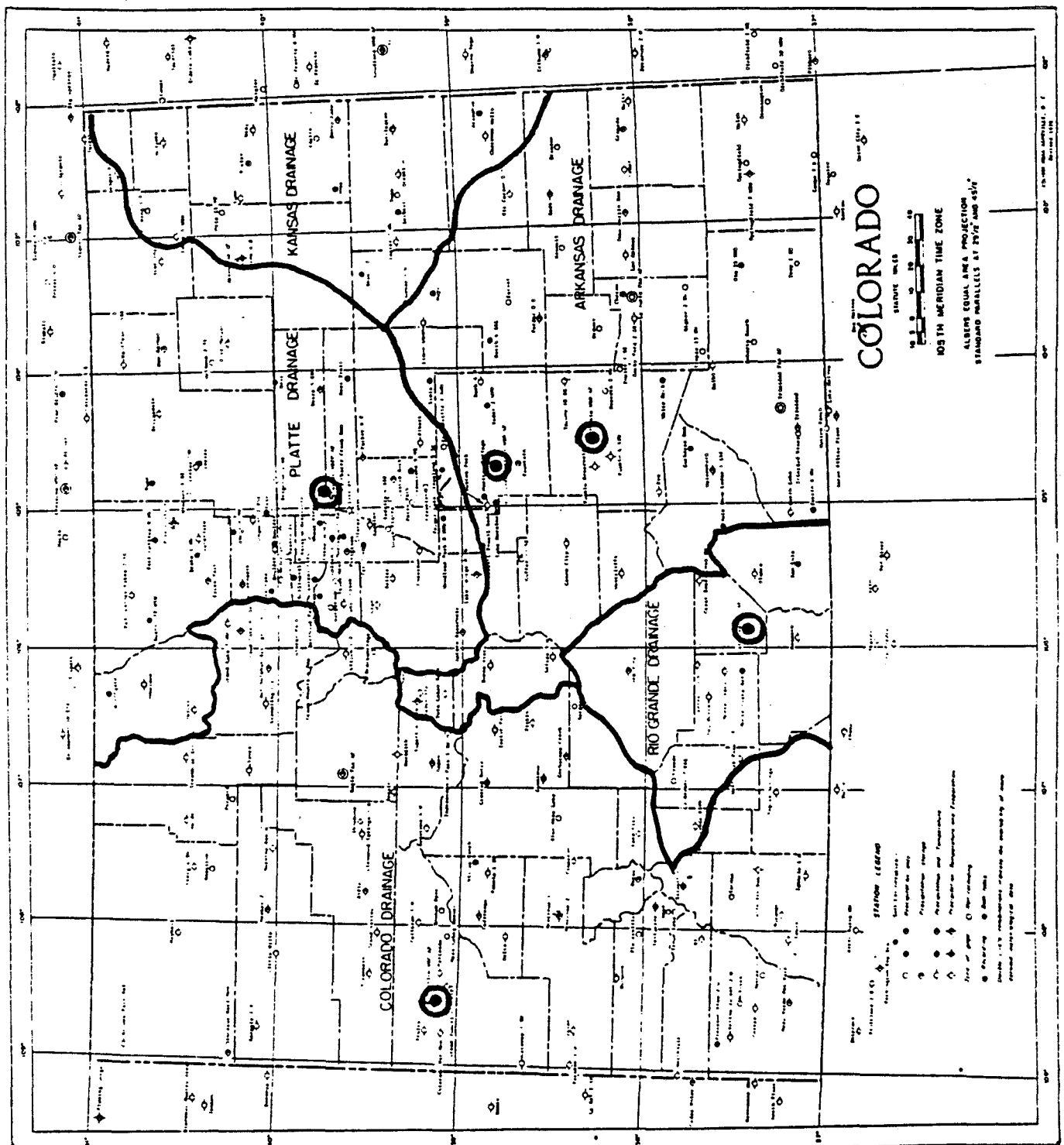
Table D.1. should be used by itself for all other exposed activities. Multiply the applicable emission factor by 365-table value/365.

For areas some distances from one of these major stations may use other documentation or Figure 11.2.1-1 in Section VI.

Table D.3. provides average wind speeds for the five major weather stations (17)

Station	Average Wind Speed (mph)
Alamosa	8.3
Grand Junction	8.1
Pueblo	8.7
Colorado Springs	10.4
Denver	9.0

FIGURE D 1 (17)



ADDITIONAL FACTORS

Product loss due to transportation by rail or truck = 57×10^{-6} lb/ton/mile.

Assume all emissions occur within a 50 mile radius. (18)

Demolition = 2 lb/ton Assume yd³ of debris = 1.5 ton (5)

Sand Blasting = 0.1 lb/ft² (5) or 4.1% by weight of blasted abrasive for sand,
1.0% for slag and 0.7% for steel shot. (19)

Feedlots =	>100,000 head	= 1.9 ton/1000 head/yr. (8)
	10,000-100,000	= 3.5 ton/1000 head/yr.
	1,000-10,000	= 4.6 ton/1000 head/yr.
	<100	= 7.3 ton/1000 head/yr.

REFERENCES

- (1) Conversation with Roger Steen of Air Sciences
- (2) Conversation with Al Morris of Ambient Analysis, Inc.
- (3) Chalekode, P.K. and Peters J.A. Monsanto Research Corp., Dayton, Ohio. Assessment of Open Sources.
- (4) PEDco - Environmental Specialists, Inc., April 1976. Evaluation of Fugitive Dust Emissions from Mining, Task 1 Report, Identification of Fugitive Dust Sources Associated with Mining, Contract No. 68-02-1321, Task No. 36 for U.S.E.P.A., Cinn., Ohio.
- (5) Engineering estimate based on field observations and data comparison by Air Pollution Control Division of the Colorado Department of Health.
- (6) Summary of Past BACT Determinations Made by Region VIII for Large Surface Coal and Uranium Operations. Table 1.
- (7) Midwest Research Institute, August 1977. A Study of Fugitive Emissions from Metallurgical Processes. Contract No. 68-02-2120 for Industrial Environmental Research Laboratory, E.P.A., R.T.P., North Carolina.
- (8) PEDco - Investigation of Fugitive Dust - Sources, Emissions and Control - for Attainment of Secondary Ambient Air Quality Standards, Colorado (1973) Contract No. 68-02-0044 Task Order No. 16 for E.P.A., R.T.P., N. Carolina.
- (9) Weant, George E. and Carpenter, B.H., Research Triangle Institute, R.T.P., N. Carolina, Fugitive Dust Emissions and Control
- (10) Permit Processing Memo No. 20, Inter-Office Communication, APCD, from Gary McCutchen and John Clouse.
- (11) Source Assessment - Crushed Sandstone, Quartz and Quartzite - State of the Art, May 1978, E.P.A. - 600/2-78-004n. Industrial Environmental Research Laboratory, Cinn., Ohio.
- (12) PEDCo and Midwest Research Institute, Improved Emission Factors for Fugitive Dust from Mining Sources, First Draft, Contract No. 68-03-2924 for E.P.A., OAQPS, R.T.P., N. Carolina
- (13) Soils Manual for Design of Asphalt Pavement Structures (MS-10) February 1969 by the Asphalt Institute, College Park, Maryland.

- (14) Producers Fact Book, 1980, for the aggregates producer by Universal Engineering Corporation, Cedar Rapids, Iowa.
- (15) PEDco, Feb. 1978, Survey of Fugitive Dust from Coal Mines, Contract No. 68-01-4489 Project No. 3311 for E.P.A., Region VIII, Office of Energy Activities, Denver, Colo.
- (16) Assorted manufacturer's brochures.
- (17) Climatological Data, 1981, for Colorado, N.O.A.A.
- (18) L. E. Paulson, et al, Experiences in Transportaion of Dried Low-Rank Western Coals from Sociency of Mining Engineers, AIME Dec. 1976.
- (19) State of California, Air Resources Board, Feb. 23, 1984, Abrasive Blasting.

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APPENDIX 3
DISPERSION CALCULATION

A3.1 INTRODUCTION

In order to determine the intake concentration of principal contaminants (PCs) at the RFP site fenceline (receptor location), Turner's X/Q model was used for contaminant dispersion from the source (Turner, 1967). These gaussian dispersion functions are the basis of most air dispersion models used in environmental work. As applied, Turner's equation is conservative and tends to over estimate exposure concentrations. The RFP air data was used as the best available. As discussed in Appendix 2, dust emission rates were determined at the source of site activities based on the predictions of various fugitive dust emission models (VOCs were assumed to be completely volatilized during activities which disturbed VOC-contaminated soil). The application of Turner's X/Q model to these source emission rates is discussed in the following sections.

A3.2 DISPERSION CALCULATIONS

Turner's X/Q model is expressed as follows:

$$\text{Concentration (g/m}^3\text{)} = \frac{Q}{\pi \sigma_y \sigma_z U}$$

Q	=	Emission rate of PC at source, (g/s or pCi/s)
π	=	3.14
σ_y	=	Horizontal dispersion coefficient, (m)
σ_z	=	Vertical dispersion coefficient, (m)
U	=	Average wind speed, m/s

The emission rate of a PC at the source, Q, can be determined based on three parameters:

1. concentration of a particular PC in the soil being disturbed by an activity;
2. fugitive dust emission factor for the activity (or complete volatilization for VOCs); and
3. duration of the activity.

An example calculation of Q is as follows.

Assume:

- PC exists at 1 ppm in soil being disturbed;
- dust model predicts an emission of 0.5 kg soil/1 Mg soil disturbed;
- activity duration of 10 hours (36,000s); and
- total soil disturbed over duration of activity is 10 Mg.

Therefore:

$$Q = \frac{0.5 \text{ kg soil}}{1 \text{ Mg Soil Disturbed}} \times \frac{10 \text{ Mg Soil Disturbed}}{36,000\text{s}} \times \frac{1\text{g PC}}{1,000 \text{ kg soil}} = \frac{1.4\text{E-}7 \text{ gPCemitted}}{\text{s}}$$

σ_y and σ_z can be determined as a function of distance between the source of contamination and the receptor (see Attachment A.3.1). In modeling dispersions from activities at RFP, four distances were derived based on the expected areas of activity (Zones A, B, and C and Operable Unit 3). These distances were made conservative by assuming the center of activity for each of the zones is located at the zone's boundary nearest to the off-site receptor where it intersects the wind vector leading to the receptor. The wind vector along which dispersion modeling was performed represents the most common wind direction at the RFP. The distance to

the receptor for Operable Unit 3 activities is assumed to be one-half mile (0.8 km) based on a source of activity (well drilling and vehicle traffic) located just east of Indiana Street and a receptor in the vicinity of Standley Reservoir. Table A.3-1 summarizes the distances assumed and their corresponding σ_y and σ_z values.

TABLE A.3-1

AREA	DISTANCE TO RECEPTOR (km)	σ_y (m)	σ_z (m)
Zone A	1.6	110	43
Zone B	2.9	182	64
Zone C	4.4	270	82
Operable Unit 3	0.8	55	26

The mean wind speed, U, was estimated as follows using available wind rose data for RFP for 1990 (see Attachment A.3.2 - Wind Rose for RFP-1990). Note that the wind speed data was presented in knots, and that stability Class D was assumed.

$$\begin{aligned}
 U_{AVG} &= 0.066(1.5) + 0.266(4.5) + 0.319(8.0) + 0.219(13) + 0.070(18.5) + 0.059(21) \\
 &= 9.2 \text{ knots (4.7 m/s)}
 \end{aligned}$$

A.3.3 SUMMARY

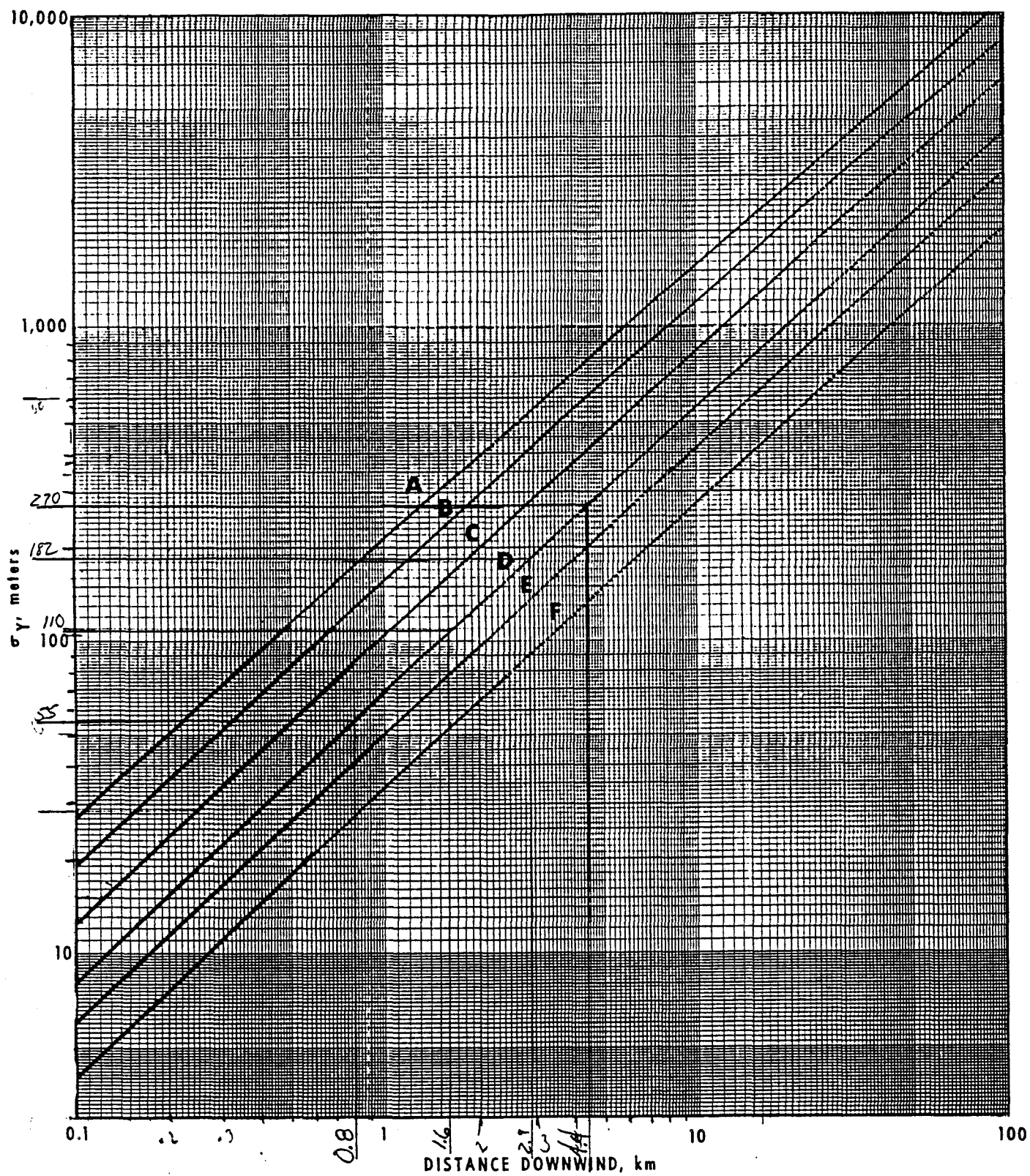
PC concentrations at the receptor were determined by applying the aforementioned Turner's X/Q model to the emission rates (Q) of the PCs at the various sources. The model was applied separately to the source emission rates for radionuclides, non-radionuclides, and VOCs. Actual application of this model is detailed for Zones A, B, and C and Operable Unit 3 in Attachments A.3.3, A.3.4,

A.3.5, and A.3.6, respectively. These attachments are spreadsheets developed to calculate dust emission factors, dose intakes, risks and soil threshold levels for each of the identified activities.

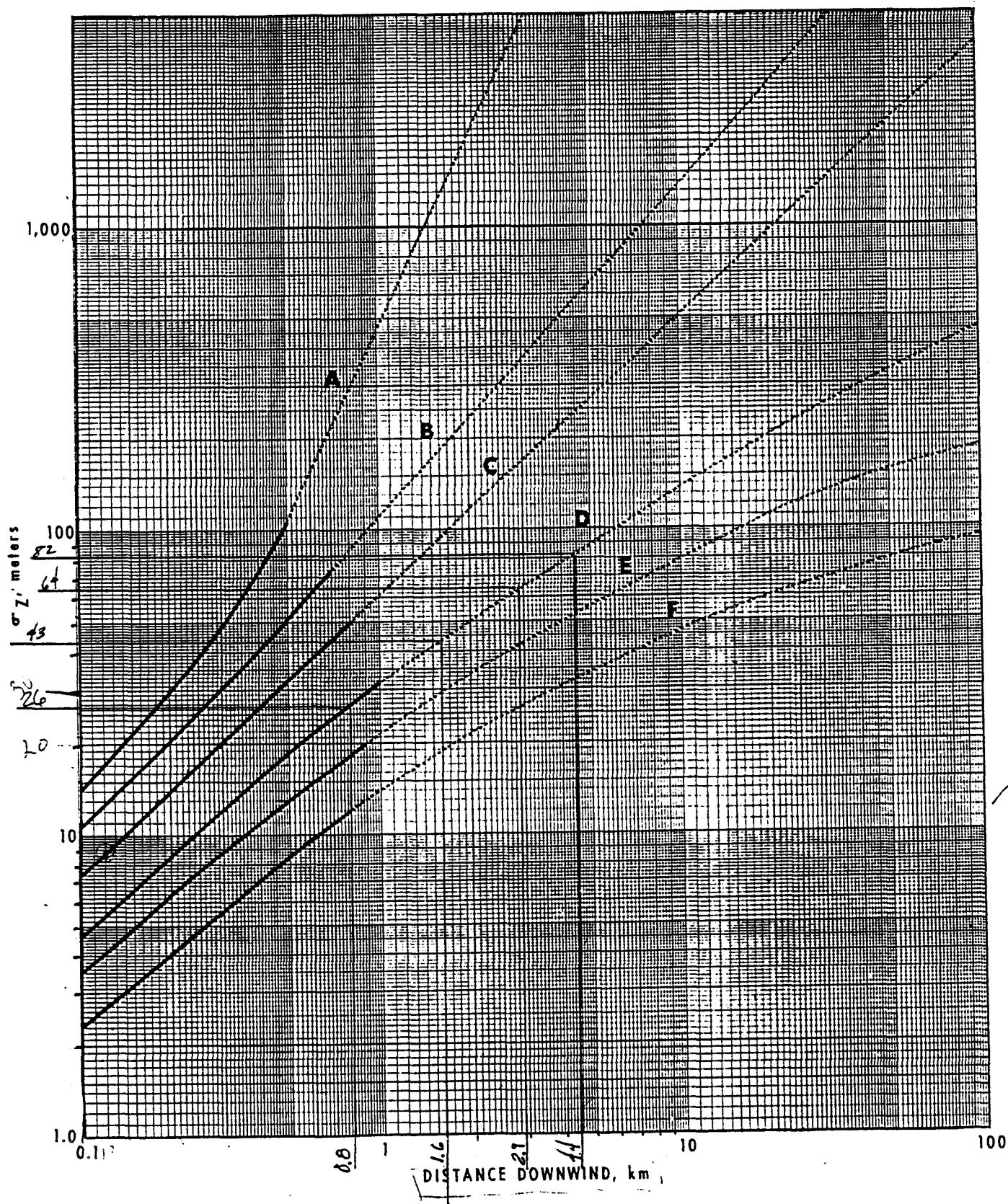
A.3.4 REFERENCES

Turner, D.B., 1967. Workbook of Atmospheric Dispersion Estimates, Public Health Service, Publication 999-AP-26, Cincinnati, Ohio: Robert A. Taft Sanitary Engineering Center.

ATTACHMENT A.3.1
 σ_y and σ_z

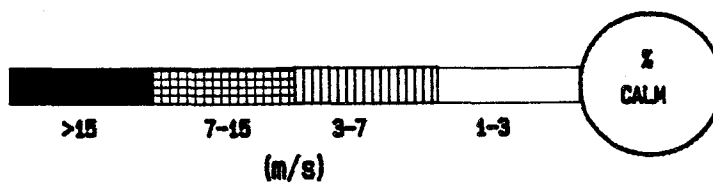


Horizontal dispersion coefficient as a function of downwind distance from the source.



Vertical dispersion coefficient as a function of downwind distance from the source.

ATTACHMENT A.3.2
WIND ROSE



ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS A

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	>21.0		
N	5.2	2.1	.0	.0	.0	.0	7.34	.33
NNE	7.3	3.7	.0	.0	.0	.0	11.01	.49
NE	8.7	3.8	.0	.0	.0	.0	12.54	.56
ENE	7.0	3.8	.0	.0	.0	.0	10.86	.48
E	14.2	5.8	.0	.0	.0	.0	20.03	.89
ESE	7.6	3.5	.0	.0	.0	.0	11.01	.49
SE	7.4	2.1	.0	.0	.0	.0	9.48	.42
SSE	3.7	.6	.0	.0	.0	.0	4.28	.19
S	2.9	.6	.0	.0	.0	.0	3.52	.16
SSW	1.7	.0	.0	.0	.0	.0	1.68	.07
SW	.4	.4	.0	.0	.0	.0	.76	.03
WSW	.9	.0	.0	.0	.0	.0	.92	.04
W	.6	.1	.0	.0	.0	.0	.76	.03
WNW	.9	.1	.0	.0	.0	.0	1.07	.05
NW	1.6	.4	.0	.0	.0	.0	1.99	.09
NNW	2.3	.5	.0	.0	.0	.0	2.75	.12
ALL	72.5	27.5	.0	.0	.0	.0	100.00	4.43

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 1
TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 811

ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS B

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	>21.0		
N	1.5	3.9	.2	.0	.0	.0	5.62	.14
NNE	2.8	5.7	.5	.0	.0	.0	8.89	.21
NE	3.2	12.0	.0	.0	.0	.0	15.24	.37
ENE	3.8	9.3	.0	.0	.0	.0	13.13	.32
E	4.0	15.9	.0	.0	.0	.0	19.92	.48
ESE	4.3	10.9	.2	.0	.0	.0	15.46	.37
SE	2.9	3.6	.2	.0	.0	.0	6.79	.16
SSE	.5	2.3	.0	.0	.0	.0	2.81	.07
S	1.7	.7	.2	.0	.0	.0	2.57	.06
SSW	1.0	1.1	.0	.0	.0	.0	2.11	.05
SW	.5	.2	.2	.0	.0	.0	.93	.02
WSW	.7	.0	.0	.0	.0	.0	.70	.02
W	.7	.0	.2	.0	.0	.0	.93	.02
WNW	.7	.2	.5	.0	.0	.0	1.39	.03
NW	.5	.7	.0	.0	.0	.0	1.17	.03
NNW	.7	1.1	.5	.0	.0	.0	2.33	.06
ALL	29.6	67.6	2.7	.0	.0	.0	100.00	2.41

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 0
TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 441

ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS C

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	>21.0		
N	.8	4.0	.6	.0	.0	.0	5.43	.34
NNE	1.6	9.0	.7	.0	.0	.0	11.32	.71
NE	1.4	10.4	.7	.0	.0	.0	12.48	.78
ENE	2.1	9.1	.3	.0	.0	.0	11.51	.72
E	2.1	13.3	.3	.0	.0	.0	15.70	.99
ESE	1.7	10.3	.4	.1	.0	.0	12.57	.79
SE	2.1	8.7	.4	.1	.0	.0	11.32	.71
SSE	1.2	3.0	.2	.0	.0	.0	4.28	.27
S	.6	2.1	.2	.0	.0	.0	2.85	.18
SSW	.6	.9	.3	.0	.0	.0	1.78	.11
SW	.1	.6	.3	.0	.0	.0	.97	.06
WSW	.4	.3	.3	.0	.0	.0	.89	.06
W	.2	.6	.3	.0	.0	.0	1.15	.07
WNW	.6	.5	.1	.1	.0	.0	1.25	.08
NW	.9	1.7	.7	.0	.0	.0	3.28	.21
NNW	.9	2.0	.3	.0	.0	.0	3.20	.20
ALL	17.2	76.4	6.1	.3	.0	.0	100.00	6.29

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 0
TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 1151

ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS D

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	>21.0		
N	.6	2.6	4.1	2.4	.4	.4	10.41	6.91
NNE	.7	3.0	3.5	1.5	.1	.0	8.71	5.78
NE	.5	2.5	2.0	.5	.0	.0	5.55	3.68
ENE	.5	1.4	1.0	.1	.0	.0	3.11	2.06
E	.5	1.9	.9	.0	.0	.0	3.42	2.27
ESE	.4	2.2	2.5	.2	.0	.0	5.23	3.47
SE	.4	3.3	4.9	1.0	.0	.0	9.53	6.33
SSE	.5	2.6	3.4	.9	.1	.0	7.59	5.04
S	.4	1.6	1.4	.8	.1	.0	4.35	2.89
SSW	.3	1.0	.8	.4	.1	.0	2.58	1.71
SW	.2	.6	.7	.6	.2	.0	2.40	1.60
WSW	.2	.5	.5	1.4	.6	.4	3.57	2.37
W	.4	.4	.6	2.4	1.6	2.2	7.68	5.10
WNW	.2	.6	1.2	4.4	2.7	2.4	11.53	7.66
NW	.4	1.1	1.7	3.5	1.0	.3	8.05	5.34
NNW	.3	1.4	2.6	1.7	.2	.0	6.30	4.18
ALL	6.6	26.6	31.9	21.9	7.0	5.9	100.00	66.40

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 14
TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 12154

ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS E

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	≥21.0		
N	.8	2.5	4.6	.0	.0	.0	7.81	1.16
NNE	1.0	3.5	3.5	.0	.0	.0	7.90	1.17
NE	.7	3.0	1.5	.0	.0	.0	5.21	.77
ENE	.8	2.1	.6	.0	.0	.0	3.59	.53
E	1.1	1.1	.3	.0	.0	.0	2.56	.38
ESE	.4	1.4	1.2	.0	.0	.0	2.91	.43
SE	.4	2.5	1.9	.0	.0	.0	4.85	.72
SSE	.8	1.8	2.5	.0	.0	.0	5.13	.76
S	1.1	2.1	3.7	.0	.0	.0	6.96	1.03
SSW	.5	1.2	3.3	.0	.0	.0	4.94	.73
SW	.8	1.4	5.0	.0	.0	.0	7.22	1.07
WSW	.8	1.7	5.8	.0	.0	.0	8.22	1.22
W	.9	2.0	4.2	.0	.0	.0	7.02	1.04
WNW	.9	2.0	4.5	.0	.0	.0	7.51	1.11
NW	.9	2.4	5.8	.0	.0	.0	9.15	1.35
NNW	1.2	2.5	5.4	.0	.0	.0	9.01	1.33
ALL	13.1	33.2	53.8	.0	.0	.0	100.00	14.79

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 2
TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 2708

ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS F

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	>21.0		
N	.4	6.8	.0	.0	.0	.0	7.20	.38
NNE	.3	2.1	.0	.0	.0	.0	2.33	.12
NE	.6	1.8	.0	.0	.0	.0	2.43	.13
ENE	.4	1.0	.0	.0	.0	.0	1.38	.07
E	.2	.5	.0	.0	.0	.0	.74	.04
ESE	.2	.3	.0	.0	.0	.0	.53	.03
SE	.3	3.4	.0	.0	.0	.0	3.70	.20
SSE	1.3	4.6	.0	.0	.0	.0	5.93	.32
S	1.0	7.7	.0	.0	.0	.0	8.68	.46
SSW	1.0	6.4	.0	.0	.0	.0	7.41	.39
SW	.8	8.6	.0	.0	.0	.0	9.42	.50
WSW	1.2	8.8	.0	.0	.0	.0	10.05	.54
W	1.5	9.7	.0	.0	.0	.0	11.22	.60
WNW	1.9	9.9	.0	.0	.0	.0	11.85	.63
NW	1.5	7.7	.0	.0	.0	.0	9.21	.49
NNW	.7	7.3	.0	.0	.0	.0	7.94	.42
ALL	13.3	86.7	.0	.0	.0	.0	100.00	5.33

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 1
TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 975

ROCKY FLATS METEOROLOGICAL MONITORING STATION
60 METER TOWER

JANUARY 1, 1990 - DECEMBER 31, 1990

WIND FREQUENCY DISTRIBUTION BY PERCENT - STABILITY CLASS ALL

10 METER LEVEL

WIND DIRECTION	WIND SPEED CLASSES (KNOTS)						CLASS*	TOTAL**
	<3.0	3.0- <6.0	6.0- <10.0	10.0- <16.0	16.0- <21.0	>21.0		
N	.8	2.9	3.4	1.6	.2	.2	9.29	9.25
NNE	1.1	3.5	2.9	1.0	.0	.0	8.52	8.49
NE	1.1	3.3	1.6	.3	.0	.0	6.31	6.29
ENE	1.0	2.3	.8	.1	.0	.0	4.20	4.19
E	1.4	3.0	.7	.0	.0	.0	5.06	5.04
ESE	.9	2.7	1.9	.1	.0	.0	5.60	5.58
SE	.9	3.5	3.6	.6	.0	.0	8.57	8.54
SSE	.8	2.5	2.6	.6	.1	.0	6.66	6.64
S	.7	2.0	1.5	.5	.1	.0	4.79	4.78
SSW	.5	1.2	1.0	.3	.1	.0	3.09	3.08
SW	.3	1.2	1.2	.4	.1	.0	3.29	3.28
WSW	.4	1.1	1.2	1.0	.4	.3	4.25	4.24
W	.5	1.1	1.1	1.6	1.1	1.5	6.89	6.87
WNW	.5	1.3	1.5	3.0	1.8	1.6	9.59	9.56
NW	.7	1.6	2.1	2.3	.7	.2	7.54	7.51
NNW	.6	1.9	2.6	1.1	.1	.0	6.34	6.32
ALL	12.1	35.0	29.7	14.6	4.7	3.9	100.00	99.64

CALMS ARE DISTRIBUTED AS PER NCDC STAR DECK PROCEDURES

* TOTAL PERCENT FOR THIS STABILITY CLASS

** TOTAL PERCENT RELATIVE TO ALL STABILITY CLASSES

TOTAL NUMBER OF INVALID OBSERVATIONS IN THIS STABILITY CLASS = 18

TOTAL NUMBER OF VALID OBSERVATIONS IN THIS STABILITY CLASS = 18240

JOINT DATA RECOVERY RATE = 99.9%

ATTACHMENT A.3.3
ZONE A CALCULATIONS

----- = variables requiring input

DESCRIPTION: The equation for hole drilling predicts emissions on a per hole basis.

HOLE DRILLING - ZONE A

For Reptable Fines <=15um
EHE(kg/hole) = 0.25 (note 1)

Variable	Unit	Parameter
D, Depth of Hole	m	9
DI, Diameter of Hole	m	0.3
DT, Bulk Density of Soil	Mg/m ³	1.5
T, Total Period of Hole Drilling	hr	10
MT, Total Mass of Soil Removed	Mg	0.42
VOC Total (note 2)	g	0.42
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/hole	2.50E-01
Non-Radionuclide (solids) Emission Rate	g/h	6.94E-09
Radionuclide Emission Rate (note 4)	pCi/h	6.94E-03
VOCs Emission Rate	g/h	1.18E-05

Note 1: Reference Memorandum from Tom Twitink, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	6.94E-09	Receptor @ 1.64 km
Q2, Emission Rate - Radionuclides	pCi/sec.	6.94E-03	
Q3, Emission Rate - VOCs	g/sec.	1.18E-05	
Pi		3.14	
Sigma y	m	110	Class D stability
Sigma z	m	43	Class D stability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fence Line			
Non-Radionuclides	mg/m ³	9.95E-11	
Radionuclides	pCi/m ³	9.95E-08	
VOCs	mg/m ³	1.69E-07	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

HOLE DRILLING - ZONE A

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	9.95E-08
Intake/Exposure Period	pCi	8.71E-04
EPA L.E.C.R.		
Uranium 233 & 234		2E-11
Uranium 235		2E-11
Uranium 238		2E-11
Americium 241		3E-11
Plutonium 239 & 240		4E-11
Tritium (gas)**		7E-17
Strontium 89		3E-15
Strontium 90		5E-14
Cesium 137		4E-14
Radium 226		3E-12
Radium 228		6E-13

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	9.95E-11
Intake/Exposure Period	mg	8.71E-07
Carcinogen Dose Rate	mg/kg/day	4.87E-13
Non-Carc. Dose Rate	mg/kg/day	6.82E-12
EPA L.E.C.R.		
Arsenic		2E-11
Beryllium		4E-12
Cadmium		3E-12
Chromium VI		2E-12
a-Hexachlorocyclohexane		3E-12
B-Hexachlorocyclohexane		9E-13
Heptachlor		2E-12
Heptachlor Epoxide		4E-12
Aldrin		8E-12
Dieldrin		8E-13
DDT		2E-13
Chlordane (alpha, gamma)		6E-13
Toxaphene		5E-13
Hazard Quotient		
Barium		7E-09
Chromium III		1E-06
Chromium VI		1E-06
Manganese		6E-08
Mercury		8E-08

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	1.69E-07
Intake/Exposure Period	mg	1.48E-03
Carcinogen Dose Rate	mg/kg/day	8.26E-10
Non-Carc. Dose Rate	mg/kg/day	1.16E-08
EPA L.E.C.R.		
Chloroform		7E-11
Carbon Tetrachloride		1E-10
Benzene		2E-11
Dichloromethane		2E-12
1,2-Dichloroethane		8E-11
1,1-Dichloroethene		1E-09
1,3-Dichloropropene		1E-10
1,1,2-Trichloroethane		5E-11
Bromoform		3E-12
Tetrachloroethene		1E-12
Styrene		2E-12
Vinyl Chloride		2E-11
1,2-Dichloroethane		8E-11
1,2-Dichloropropane		1E-10
1,1,2,2-Tetrachloroethane		2E-10
2-Chloroethyl Ether		9E-10
Hexachlorethane		1E-11
Hexachlorobutadiene		6E-11
2,4,6-Trichlorophenol		9E-12
Hexachlorobenzene		1E-09
Hazard Quotient		
1,1,1-Trichloroethane		4E-09
Toluene		2E-08
Dichloromethane		1E-08
Xylenes		1E-07
MEK		1E-08
Bromomethane		6E-07
Carbon Disulfide		4E-06
1,1-Dichloroethane		1E-08
Vinyl Acetate		2E-07
1,3-Dichloropropene		2E-06
Chlorobenzene		2E-07
Ethylbenzene		4E-08
1,4-Dichlorobenzene		6E-08
1,2-Dichlorobenzene		3E-08
Nitrobenzene		2E-06
1,2,4-Trichlorobenzene		4E-07
Hexachlorocyclopentadiene		6E-05

HOLE DRILLING - ZONE A
EPA Threshold Levels

L.E.C.R **HI**
Threshold Conc. **Threshold Conc.**

Radionuclides

pCi/g

Uranium 233 & 234	4.25E+04
Uranium 235	4.59E+04
Uranium 238	4.78E+04
Americium 241	2.87E+04
Plutonium 239 & 240	2.80E+04
Tritium (gas)**	1.47E+10
Strontium 89	3.96E+08
Strontium 90	2.05E+07
Cesium 137	2.34E+07
Radium 226	3.82E+05
Radium 228	1.77E+06

Non-Radionuclides

ug/g

ug/g

Arsenic	4.10E+04	
Barium		1.47E+07
Beryllium	2.44E+05	
Cadmium	3.36E+05	
Chromium III		8.36E+04
Chromium VI	5.01E+05	8.36E+04
Manganese		1.67E+06
Mercury		1.26E+06
Hexachlorocyclohexane (alpha)	3.26E+05	
Hexachlorocyclohexane (beta)	1.14E+06	
Heptachlor	4.56E+05	
Heptachlor Epoxide	2.26E+05	
Aldrin	1.21E+05	
Dieldrin	1.28E+06	
DDT	6.04E+06	
Chlordane (alpha, gamma)	1.58E+06	
Toxaphene	1.87E+06	

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform	1.49E+04	2.59E+07
1,1,1-Trichloroethane		
Carbon Tetrachloride	9.31E+03	
Benzene	4.03E+04	
Toluene		5.19E+06
Dichloromethane	6.05E+05	7.78E+06
Xylenes		7.78E+05
MEK		7.78E+06
1,2-Dichloroethane	1.33E+04	
Bromomethane		1.73E+05
Carbon Disulfide		2.59E+04
1,1-Dichloroethene	1.01E+03	
1,1-Dichloroethane		8.65E+06
Vinyl Acetate		5.19E+05
1,3-Dichloropropene	9.31E+03	5.19E+04
1,1,2-Trichloroethane	2.12E+04	
Bromoform	3.10E+05	
Tetrachloroethene	6.72E+05	
Chlorobenzene		4.32E+05
Ethylbenzene		2.59E+06
Styrene	6.05E+05	
Vinyl Chloride	4.17E+04	
1,2-Dichloroethane	1.33E+04	
1,2-Dichloropropane	9.31E+03	
1,1,2,2-Tetrachloroethane	6.05E+03	
2-Chloroethyl Ether	1.10E+03	
1,4-Dichlorobenzene		1.73E+06
1,2-Dichlorobenzene		3.46E+06
Nitrobenzene		5.19E+04
Hexachloroethane	8.65E+04	
1,2,4-Trichlorobenzene		2.59E+05
Hexachlorobutadiene	1.55E+04	
Hexachlorocyclopentadiene		1.73E+03
2,4,6-Trichlorophenol	1.10E+05	
Hexachlorobenzene	7.56E+02	

DESCRIPTION: The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation >= .254mm.

----- = variables requiring input

Vehicle Traffic - $1.1 \times 10^{-4} \times V \times W \times D \times P$ - Zone A

For Respirable Fines <= 10um, K = 0.45
 $E_{HF}(kg/VKT) = K(1.7)(s/12)(S/48)(W/2.7) \wedge .7(w/4) \wedge .5((365-p)/365)$ (note 1)

Variable	Unit	Parameter
S, Silt Content	%	56.1
S, Mean Vehicle Speed	km/hr	16
W, Mean Vehicle Weight	Mg	2.7
P, Mean Number of Wheels		4
P, Days with Prec. >= .254mm	hr	40
T, Duration of Activity	km	10
D, Total Vehicle Distance Travelled		10
VOC Total (note 2)		0.00

Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/h	2.63E-07
Radionuclide Emission Rate (note 4)	pCi/h	2.63E-01
VOCs Emission Rate	g/h	0.00E+00

Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-07	Receptor @ 1.64 km
Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E-01	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
P1		3.14	
Sigma y	m	110	Class D stability
Sigma z	m	43	Class D stability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m^3	3.77E-09	
Radionuclides	pCi/m^3	3.77E-06	
VOCs	mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

Note 1: Reference Memorandum from Tom Tutin, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs emissions are assumed to be negligible for this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Vehicle Traffic - Light(10 VKT/Day) - Zone A

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	3.77E-06	
Intake/Exposure Period	pCi	3.30E-02	
EPA L.E.C.R.			
Uranium 233 & 234		9E-10	
Uranium 235		8E-10	
Uranium 238		8E-10	
Americium 241		1E-09	
Plutonium 239 & 240		1E-09	
Tritium (gas)**		3E-15	
Strontium 89		1E-13	
Strontium 90		2E-12	
Cesium 137		2E-12	
Radium 226		1E-10	
Radium 228		2E-11	
Dose/Risk Estimates - Non - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.77E-09	
Intake/Exposure Period	mg	3.30E-05	
Carcinogen Dose Rate	mg/kg/day	1.85E-11	
Non - Carc. Dose Rate	mg/kg/day	2.59E-10	
EPA L.E.C.R.			
Arsenic		9E-10	
Beryllium		2E-10	
Cadmium		1E-10	
Chromium VI		8E-11	
a - Hexachlorocyclohexane		1E-10	
B - Hexachlorocyclohexane		3E-11	
Heptachlor		8E-11	
Heptachlor Epoxide		2E-10	
Aldrin		3E-10	
Dieldrin		3E-11	
DDT		6E-12	
Chlordane (alpha, gamma)		2E-11	
Toxaphene		2E-11	
Hazard Quotient			
Barium		3E-07	
Chromium III		5E-05	
Chromium VI		5E-05	
Manganese		2E-06	
Mercury		3E-06	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non - Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA L.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2-Dichloroethane		0E+00	
1,1-Dichloroethene		0E+00	
1,3-Dichloropropene		0E+00	
1,1,2-Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2-Dichloroethane		0E+00	
1,2-Dichloropropane		0E+00	
1,1,2,2-Tetrachloroethane		0E+00	
2-Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6-Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1-Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1-Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3-Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4-Dichlorobenzene		0E+00	
1,2-Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4-Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

Vehicle Traffic - Light(10 VKT/Day) - Zone A
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	1.12E+03	
Uranium 235	1.21E+03	
Uranium 238	1.26E+03	
Americium 241	7.57E+02	
Plutonium 239 & 240	7.38E+02	
Tritium (gas)**	3.88E+08	
Strontium 89	1.04E+07	
Strontium 90	5.40E+05	
Cesium 137	6.18E+05	
Radium 226	1.01E+04	
Radium 228	4.66E+04	
Non - Radionuclides	ug/g	ug/g
Arsenic	1.08E+03	
Barium		3.87E+05
Beryllium	6.44E+03	
Cadmium	8.87E+03	
Chromium III		2.20E+03
Chromium VI	1.32E+04	2.20E+03
Manganese		4.41E+04
Mercury		3.32E+04
Hexachlorocyclohexane (alpha)	8.59E+03	
Hexachlorocyclohexane (beta)	3.01E+04	
Heptachlor	1.20E+04	
Heptachlor Epoxide	5.95E+03	
Aldrin	3.18E+03	
Dieldrin	3.38E+04	
DDT	1.59E+05	
Chlordane (alpha, gamma)	4.16E+04	
Toxaphene	4.92E+04	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation >= 254mm.

DESCRIPTION:

Vehicle Traffic - Heavy (100 V.KT/Day) - Zone A

For Respirable Finest <= 10um, K = 0.45
 $EHE(kg/VKT) = K(1.7)(s/42)(S/48)(W/2.7)^{-1} \cdot X(365-p)/365$ (note 1)

Variable	Unit	Parameter
S, Silt Content	%	50.1
S, Mean Vehicle Speed	km/hr	16
W, Mean Vehicle Weight	Mg	2.7
P, Mean Number of Wheels		4
P, Days with Prec. >= 0.254mm	hr	40
T, Duration of Activity	km	10
D, Total Vehicle Distance Travelled		100
VOC Total (note 2)		0.00

Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/s	2.63E-06
Radionuclide Emission Rate (note 4)	pCi/s	2.63E+00
VOCs Emission Rate	g/s	0.00E+00

The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation >= 254mm.

Turners X/Q	Contaminant Dispersion Variable	Unit	Parameter	Remark
	Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-06	Receptor @ 1.64 km
	Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E+00	
	Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
	P1		3.14	
	Sigma y	m	110	Class D stability
	Sigma z	m	43	Class D stability
	Wind speed	m/sec	4.7	
	Contaminant Concentrations at Fenceline			
	Non-Radionuclides	mg/m ³	3.77E-08	
	Radionuclides	pCi/m ³	3.77E-05	
	VOCs	mg/m ³	0.00E+00	
	Initial Concentrations of Contaminants in Soils at Source			
	Radionuclides (pCi/g)	1.00E+00		
	Non-Rad's (ug/g or ppm)	1.00E+00		
	VOCs (ug/g or ppm)	1.00E+00		

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

Note 1: Reference Memorandum from Tom Tatlinic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs emissions are assumed to be negligible for this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Vehicle Traffic - Heavy(100 VKT/Day) - Zone A

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	3.77E-05	
Intake/Exposure Period	pCi	3.30E-01	
EPA L.E.C.R.			
Uranium 233 & 234		9E-09	
Uranium 235		8E-09	
Uranium 238		8E-09	
Americium 241		1E-08	
Plutonium 239 & 240		1E-08	
Tritium (gs)**		3E-14	
Strontium 89		1E-12	
Strontium 90		2E-11	
Cesium 137		2E-11	
Radium 226		1E-09	
Radium 228		2E-10	

Dose/Risk Estimates - Non - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.77E-08	
Intake/Exposure Period	mg	3.30E-04	
Carcinogen Dose Rate	mg/kg/day	1.85E-10	
Non - Carc. Dose Rate	mg/kg/day	2.59E-09	
EPA L.E.C.R.			
Arsenic		9E-09	
Beryllium		2E-09	
Cadmium		1E-09	
Chromium VI		8E-10	
a - Hexachlorocyclohexane		1E-09	
B - Hexachlorocyclohexane		3E-10	
Heptachlor		8E-10	
Heptachlor Epoxide		2E-09	
Aldrin		3E-09	
Dieldrin		3E-10	
DDT		6E-11	
Chlordane (alpha, gamma)		2E-10	
Toxaphene		2E-10	
Hazard Quotient			
Barium		3E-06	
Chromium III		5E-04	
Chromium VI		5E-04	
Manganese		2E-05	
Mercury		3E-05	

Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non - Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA L.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2-Dichloroethane		0E+00	
1,1-Dichloroethene		0E+00	
1,3-Dichloropropene		0E+00	
1,1,2-Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2-Dichloroethane		0E+00	
1,2-Dichloropropane		0E+00	
1,1,2,2-Tetrachloroethane		0E+00	
2-Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6-Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1-Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1-Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3-Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4-Dichlorobenzene		0E+00	
1,2-Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4-Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

Vehicle Traffic - Heavy (100 VKT/Day) - Zone A
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	1.12E+02	
Uranium 235	1.21E+02	
Uranium 238	1.26E+02	
Americium 241	7.57E+01	
Plutonium 239 & 240	7.38E+01	
Tritium (gas)**	3.88E+07	
Strontium 89	1.04E+06	
Strontium 90	5.40E+04	
Cesium 137	6.18E+04	
Radium 226	1.01E+03	
Radium 228	4.66E+03	
Non-Radionuclides	ug/g	ug/g
Arsenic	1.08E+02	
Barium		3.87E+04
Beryllium	6.44E+02	
Cadmium	8.87E+02	
Chromium III		2.20E+02
Chromium VI	1.32E+03	2.20E+02
Manganese		4.41E+03
Mercury		3.32E+03
Hexachlorocyclohexane (alpha)	8.59E+02	
Hexachlorocyclohexane (beta)	3.01E+03	
Heptachlor	1.20E+03	
Heptachlor Epoxide	5.95E+02	
Aldrin	3.18E+02	
Dieldrin	3.38E+03	
DDT	1.59E+04	
Chlordane (alpha, gamma)	4.16E+03	
Toxaphene	4.92E+03	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

DESCRIPTION: The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

Turners X/O

BATCH DROP CALCULATION - TEST PITS - ZONE A

For Reprable Flies <=15um, K = 0.48

$$EHF(\text{kg/Mg}) = K(0.0009)[(d/5)(U/2.2)(H/1.5)](M/2)^{-2}(Y/4.6)^{-.33}$$
 (note 1)

Variable	Unit	Parameter
d, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	1
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	0.25
T, Duration of Activity	hr	10
D, Depth of Excavation	m	1.22
V, Volume of Excavation	m ³	3.95
DT, Bulk Density of Soil	Mg/m ³	1.50
MT, Total Mass of Soil/Pit	Mg	5.92
VOC Total (note 2)	g	5.9
Assuming one pit constructed per day for five years gives a total number of pits equal to:		1825
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	6.44E-04
Non-Radionuclide (solids) Emission Rate	g/s	1.06E-10
Radionuclide Emission Rate (note 4)	pCi/s	1.32E-05
VOCs Emission Rate	g/s	1.65E-04

Note 1: Reference Memorandum from Tom Tustin, Public Healths Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	1.06E-10	Receptor @ 1.64 km
Q2, Emission Rate - Radionuclides	pCi/sec.	1.32E-05	
Q3, Emission Rate - VOCs	g/sec.	1.65E-04	
P1	m	3.14	
Sigma y	m	110	Class D stability
Sigma z	m	43	Class D stability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m ³	1.52E-12	
Radionuclides	pCi/m ³	1.89E-10	
VOCs	mg/m ³	2.36E-06	
Initial Concentrations of Contaminants in Soils at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

----- variables requiring input

BATCH DROP CALCULATION -- TEST FITS -- ZONE A

Dose/Risk Estimates -- Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	1.89E-10	
Intake/Exposure Period	pCi	1.66E-06	
EPA L.E.C.R.			
Uranium 233 & 234		4E-14	
Uranium 235		4E-14	
Uranium 238		4E-14	
Americium 241		7E-14	
Plutonium 239 & 240		7E-14	
Tritium (g _s)**		1E-19	
Strontium 89		5E-18	
Strontium 90		9E-17	
Cesium 137		8E-17	
Radium 226		5E-15	
Radium 228		1E-15	
Dose/Risk Estimates -- Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	1.52E-12	
Intake/Exposure Period	mg	1.33E-08	
Carcinogen Dose Rate	mg/kg/day	7.44E-15	
Non-Carc. Dose Rate	mg/kg/day	1.04E-13	
EPA L.E.C.R.			
Arsenic		4E-13	
Beryllium		6E-14	
Cadmium		5E-14	
Chromium VI		3E-14	
a-Hexachlorocyclohexane		5E-14	
B-Hexachlorocyclohexane		1E-14	
Hepachlor		3E-14	
Heptachlor Epoxide		7E-14	
Aldrin		1E-13	
Dieldrin		1E-14	
DDT		3E-15	
Chlordane (alpha, gamma)		1E-14	
Toxaphene		8E-15	
Hazard Quotient			
Barium		1E-10	
Chromium III		2E-08	
Chromium VI		2E-08	
Manganese		9E-10	
Mercury		1E-09	
Dose/Risk Estimates -- VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	2.36E-06	
Intake/Exposure Period	mg	2.07E-02	
Carcinogen Dose Rate	mg/kg/day	1.15E-08	
Non-Carc. Dose Rate	mg/kg/day	1.62E-07	
EPA L.E.C.R.			
Chloroform		9E-10	
Carbon Tetrachloride		2E-09	
Benzene		3E-10	
Dichloromethane		2E-11	
1,2-Dichloroethane		1E-09	
1,1-Dichloroethene		1E-08	
1,3-Dichloropropene		2E-09	
1,1,2-Trichloroethane		7E-10	
Bromoform		5E-11	
Tetrachloroethene		2E-11	
Styrene		2E-11	
Vinyl Chloride		3E-10	
1,2-Dichloroethane		1E-09	
1,2-Dichloropropane		2E-09	
1,1,2,2-Tetrachloroethane		2E-09	
2-Chloroethyl Ether		1E-08	
Hexachloroethane		2E-10	
Hexachlorobutadiene		9E-10	
2,4,6-Trichlorophenol		1E-10	
Hexachlorobenzene		2E-08	
Hazard Quotient			
1,1,1-Trichloroethane		5E-08	
Toluene		3E-07	
Dichloromethane		2E-07	
Xylenes		2E-06	
MEK		2E-07	
Bromomethane		8E-06	
Carbon Disulfide		5E-05	
1,1-Dichloroethane		2E-07	
Vinyl Acetate		3E-06	
1,3-Dichloropropene		3E-05	
Chlorobenzene		3E-06	
Ethylbenzene		5E-07	
1,4-Dichlorobenzene		8E-07	
1,2-Dichlorobenzene		4E-07	
Nitrobenzene		3E-05	
1,2,4-Trichlorobenzene		5E-06	
Hexachlorocyclopentadiene		8E-04	

BATCH DROP CALCULATION - TEST PITS - ZONE A

BPA Threshold Levels

L.E.C.R
Threshold Conc.

HI
Threshold Conc.

Radionuclides

pCi/g

Uranium 233 & 234	2.23E+07
Uranium 235	2.41E+07
Uranium 238	2.51E+07
Americium 241	1.51E+07
Plutonium 239 & 240	1.47E+07
Tritium (gas)**	7.74E+12
Strontium 89	2.08E+11
Strontium 90	1.08E+10
Cesium 137	1.23E+10
Radium 226	2.01E+08
Radium 228	9.28E+08

Non-Radionuclides

ug/g

ug/g

Arsenic	2.69E+06	9.60E+08
Barium		
Beryllium	1.60E+07	
Cadmium	2.20E+07	
Chromium III		5.47E+06
Chromium VI	3.28E+07	5.47E+06
Manganese		1.09E+08
Mercury		8.26E+07
Hexachlorocyclohexane (alpha)	2.13E+07	
Hexachlorocyclohexane (beta)	7.47E+07	
Heptachlor	2.99E+07	
Heptachlor Epoxide	1.48E+07	
Aldrin	7.91E+06	
Dieldrin	8.40E+07	
DDT	3.95E+08	
Chlordane (alpha, gamma)	1.03E+08	
Toxaphene	1.22E+08	

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform	1.07E+03	1.86E+06
1,1,1-Trichloroethane		
Carbon Tetrachloride	6.66E+02	
Benzene	2.89E+03	
Toluene		3.71E+05
Dichloromethane	4.33E+04	5.57E+05
Xylenes		5.57E+04
MEK		5.57E+05
1,2-Dichloroethane	9.52E+02	
Bromomethane		1.24E+04
Carbon Disulfide		1.86E+03
1,1-Dichloroethene	7.22E+01	
1,1-Dichloroethane		6.19E+05
Vinyl Acetate		3.71E+04
1,3-Dichloropropene	6.66E+02	3.71E+03
1,1,2-Trichloroethane	1.52E+03	
Bromoform	2.22E+04	
Tetrachloroethene	4.81E+04	
Chlorobenzene		3.09E+04
Ethylbenzene		1.86E+05
Styrene	4.33E+04	
Vinyl Chloride	2.99E+03	
1,2-Dichloroethane	9.52E+02	
1,2-Dichloropropane	6.66E+02	
1,1,2,2-Tetrachloroethane	4.33E+02	
2-Chloroethyl Ether	7.87E+01	
1,4-Dichlorobenzene		1.24E+05
1,2-Dichlorobenzene		2.47E+05
Nitrobenzene		3.71E+03
Hexachloroethane	6.19E+03	
1,2,4-Trichlorobenzene		1.86E+04
Hexachlorobutadiene	1.11E+03	
Hexachlorocyclopentadiene		1.24E+02
2,4,6-Trichlorophenol	7.87E+03	
Hexachlorobenzene	5.41E+01	

DESCRIPTION:

The relationship for predicting fugitive dust emissions during topsoil removal by scraper is on a per mass unit basis of soil removed.

= variables requiring input

TOPSOIL REMOVED BY SCRAPER - ZONE A

For Replatable Fines <= 15um
EHE(kg/Mg) = 0.019kg/Mg of Soil Removed (note 1)

Variable	Unit	Parameter
A, Area Subject to Topsoil Removal	m ²	29540
D, Depth of Topsoil Removal	m	0.3
DT, Bulk Density of Soil	Mg/m ³	1.5
V, Volume of Topsoil to be Removed	m ³	8862
T, Total Period of Removal	hr	317
MT, Total Mass of Topsoil Removed	Mg	13293
VOC Total (note 2)	g	13293
Emissions at Source (note 3)		
Particulate Emissions from Source	kg/Mg	1.90E-02
Non-Radionuclide (solids) Emission Rate	g/s	2.21E-07
Radionuclide Emission Rate (note 4)	pCi/s	1.10E-01
VOCs Emission Rate	g/s	1.16E-02

Turner X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.21E-07	Receptor @ 1.6 km
Q2, Emission Rate - Radionuclides	pCi/sec.	1.10E-01	
Q3, Emission Rate - VOCs	g/sec.	1.16E-02	
P1		3.14	
Sigma y	m	110	Class Datability
Sigma z	m	43	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m ³	3.17E-09	
Radionuclides	pCi/m ³	1.58E-06	
VOCs	mg/m ³	1.67E-04	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Note 1: Reference Memorandum from Tom Tulinic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984, Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

TOPSOIL REMOVED BY SCRAPER - ZONE A

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	1.58E-06
Intake/Exposure Period	pCi	1.39E-02
EPA L.E.C.R.		
Uranium 233 & 234		4E-10
Uranium 235		3E-10
Uranium 238		3E-10
Americium 241		6E-10
Plutonium 239 & 240		6E-10
Tritium (gas)**		1E-15
Strontium 89		4E-14
Strontium 90		8E-13
Cesium 137		7E-13
Radium 226		4E-11
Radium 228		9E-12

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	3.17E-09
Intake/Exposure Period	mg	2.77E-05
Carcinogen Dose Rate	mg/kg/day	1.55E-11
Non-Carc. Dose Rate	mg/kg/day	2.17E-10
EPA L.E.C.R.		
Arsenic		8E-10
Beryllium		1E-10
Cadmium		9E-11
Chromium VI		6E-11
a-Hexachlorocyclohexane		1E-10
B-Hexachlorocyclohexane		3E-11
Heptachlor		7E-11
Heptachlor Epoxide		1E-10
Aldrin		3E-10
Dieldrin		2E-11
DDT		5E-12
Chlordane (alpha, gamma)		2E-11
Toxaphene		2E-11
Hazard Quotient		
Barium		2E-07
Chromium III		4E-05
Chromium VI		4E-05
Manganese		2E-06
Mercury		3E-06

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	1.67E-04
Intake/Exposure Period	mg	1.46E+00
Carcinogen Dose Rate	mg/kg/day	8.16E-07
Non-Carc. Dose Rate	mg/kg/day	1.14E-05
EPA L.E.C.R.		
Chloroform		7E-08
Carbon Tetrachloride		1E-07
Benzene		2E-08
Dichloromethane		2E-09
1,2-Dichloroethane		7E-08
1,1-Dichloroethene		1E-06
1,3-Dichloropropene		1E-07
1,1,2-Trichloroethane		5E-08
Bromoform		3E-09
Tetrachloroethene		1E-09
Styrene		2E-09
Vinyl Chloride		2E-08
1,2-Dichloroethane		7E-08
1,2-Dichloropropene		1E-07
1,1,2,2-Tetrachloroethane		2E-07
2-Chloroethyl Ether		9E-07
Hexachlorethane		1E-08
Hexachlorobutadiene		6E-08
2,4,6-Trichlorophenol		9E-09
Hexachlorobenzene		1E-06
Hazard Quotient		
1,1,1-Trichloroethane		4E-06
Toluene		2E-05
Dichloromethane		1E-05
Xylenes		1E-04
MEK		1E-05
Bromomethane		6E-04
Carbon Disulfide		4E-03
1,1-Dichloroethane		1E-05
Vinyl Acetate		2E-04
1,3-Dichloropropene		2E-03
Chlorobenzene		2E-04
Ethylbenzene		4E-05
1,4-Dichlorobenzene		6E-05
1,2-Dichlorobenzene		3E-05
Nitrobenzene		2E-03
1,2,4-Trichlorobenzene		4E-04
Hexachlorocyclopentadiene		6E-02

TOPSOIL REMOVED BY SCRAPER - ZONE A**EPA Threshold Levels**

	L.E.C.R	HI
	Threshold Conc.	Threshold Conc.

RadionuclidespCi/g

Uranium 233 & 234	2.67E+03
Uranium 235	2.88E+03
Uranium 238	3.01E+03
Americium 241	1.80E+03
Plutonium 239 & 240	1.76E+03
Tritium (gas)**	9.25E+08
Strontium 89	2.49E+07
Strontium 90	1.29E+06
Cesium 137	1.47E+06
Radium 226	2.40E+04
Radium 228	1.11E+05

Non-Radionuclidesug/gug/g

Arsenic	1.29E+03	
Barium		4.61E+05
Beryllium	7.68E+03	
Cadmium	1.06E+04	
Chromium III		2.63E+03
Chromium VI	1.57E+04	2.63E+03
Manganese		5.25E+04
Mercury		3.96E+04
Hexachlorocyclohexane (alpha)	1.02E+04	
Hexachlorocyclohexane (beta)	3.58E+04	
Heptachlor	1.43E+04	
Heptachlor Epoxide	7.09E+03	
Aldrin	3.79E+03	
Dieldrin	4.03E+04	
DDT	1.90E+05	
Chlordane (alpha, gamma)	4.96E+04	
Toxaphene	5.86E+04	

VOCs & Semi-VOCsug/gug/g

Chloroform	1.51E+01	
1,1,1-Trichloroethane		2.63E+04
Carbon Tetrachloride	9.43E+00	
Benzene	4.08E+01	
Toluene		5.25E+03
Dichloromethane	6.13E+02	7.88E+03
Xylenes		7.88E+02
MEK		7.88E+03
1,2-Dichloroethane	1.35E+01	
Bromomethane		1.75E+02
Carbon Disulfide		2.63E+01
1,1-Dichloroethene	1.02E+00	
1,1-Dichloroethane		8.75E+03
Vinyl Acetate		5.25E+02
1,3-Dichloropropene	9.43E+00	5.25E+01
1,1,2-Trichloroethane	2.15E+01	
Bromoform	3.14E+02	
Tetrachloroethene	6.81E+02	
Chlorobenzene		4.38E+02
Ethylbenzene		2.63E+03
Styrene	6.13E+02	
Vinyl Chloride	4.23E+01	
1,2-Dichloroethane	1.35E+01	
1,2-Dichloropropane	9.43E+00	
1,1,2,2-Tetrachloroethane	6.13E+00	
2-Chloroethyl Ether	1.11E+00	
1,4-Dichlorobenzene		1.75E+03
1,2-Dichlorobenzene		3.50E+03
Nitrobenzene		5.25E+01
Hexachloroethane	8.75E+01	
1,2,4-Trichlorobenzene		2.63E+02
Hexachlorobutadiene	1.57E+01	
Hexachlorocyclopentadiene		1.75E+00
2,4,6-Trichlorophenol	1.11E+02	
Hexachlorobenzene	7.66E-01	

DESCRIPTION: The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE A

For Respirable Fines <=15um, K = 0.48
 $EHE(kg/Mg) = K(0.00099)[(45X(U/2.2)(H/1.5))((M/2)^{-2}Y(4.6)^{-0.33})]$ (note 1)

Variable	Unit	Parameter
a, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	1
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	10.70
T, Total Period of Unloading	hr	317
D, Depth of Excavation	m	0.30
A, Area of Topsoil Removed	m ²	29540
DT, Bulk Density of Soil	Mg/m ³	1.50
MT, Total Mass of Topsoil	Mg	13293
VOC Total (note 2)	g	0.0
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	1.87E-04
Non-Radionuclide (solids) Emission Rate	g/s	2.17E-09
Radionuclide Emission Rate (note 4)	pCi/s	1.09E-03
VOCs Emission Rate	g/s	0.00E+00

Note 1: Reference Memorandum from Tom Tishnic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984, Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal by scraper activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turner X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.17E-09	Receptor @ 1.64 km
Q2, Emission Rate - Radionuclides	pCi/sec.	1.09E-03	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi		3.14	
Sigma y	m	110	Class Datability
Sigma z	m	43	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Penetration			
Non-Radionuclides	mg/m ³	3.11E-11	
Radionuclides	pCi/m ³	1.55E-08	
VOCs	mg/m ³	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		0.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

= variables requiring input

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE A

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	1.55E-08	
Intake/Exposure Period	pCi	1.36E-04	
EPA L.E.C.R.			
Uranium 233 & 234		4E-12	
Uranium 235		3E-12	
Uranium 238		3E-12	
Americium 241		5E-12	
Plutonium 239 & 240		6E-12	
Tritium (gs)**		1E-17	
Strontium 89		4E-16	
Strontium 90		8E-15	
Cesium 137		7E-15	
Radium 226		4E-13	
Radium 228		9E-14	
Dose/Risk Estimates - Non - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.11E-11	
Intake/Exposure Period	mg	2.72E-07	
Carcinogen Dose Rate	mg/kg/day	1.52E-13	
Non - Carc. Dose Rate	mg/kg/day	2.13E-12	
EPA L.E.C.R.			
Arsenic		8E-12	
Beryllium		1E-12	
Cadmium		9E-13	
Chromium VI		6E-13	
a - Hexachlorocyclohexane		1E-12	
B - Hexachlorocyclohexane		3E-13	
Heptachlor		7E-13	
Heptachlor Epoxide		1E-12	
Aldrin		3E-12	
Dieldrin		2E-13	
DDT		5E-14	
Chlordane (alpha, gamma)		2E-13	
Toxaphene		2E-13	
Hazard Quotient			
Barium		2E-09	
Chromium III		4E-07	
Chromium VI		4E-07	
Manganese		2E-08	
Mercury		2E-08	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non - Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA L.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2- Dichloroethane		0E+00	
1,1- Dichloroethene		0E+00	
1,3- Dichloropropene		0E+00	
1,1,2- Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2- Dichloroethane		0E+00	
1,2- Dichloropropane		0E+00	
1,1,2,2- Tetrachloroethane		0E+00	
2- Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6- Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1- Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1- Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3- Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4- Dichlorobenzene		0E+00	
1,2- Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4- Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE A**BPA Threshold Levels****L.E.C.R****HI****Threshold Conc.****Threshold Conc.****Radionuclides****pCi/g**

Uranium 233 & 234	2.72E+05
Uranium 235	2.94E+05
Uranium 238	3.06E+05
Americium 241	1.84E+05
Plutonium 239 & 240	1.79E+05
Tritium (gas)**	9.41E+10
Strontium 89	2.53E+09
Strontium 90	1.31E+08
Cesium 137	1.50E+08
Radium 226	2.45E+06
Radium 228	1.13E+07

Non-Radionuclides**ug/g****ug/g**

Arsenic	1.31E+05	
Barium		4.69E+07
Beryllium	7.82E+05	
Cadmium	1.08E+06	
Chromium III		2.67E+05
Chromium VI	1.60E+06	2.67E+05
Manganese		5.35E+06
Mercury		4.03E+06
Hexachlorocyclohexane (alpha)	1.04E+06	
Hexachlorocyclohexane (beta)	3.65E+06	
Heptachlor	1.46E+06	
Heptachlor Epoxide	7.21E+05	
Aldrin	3.86E+05	
Dieldrin	4.10E+06	
DDT	1.93E+07	
Chlordane (alpha, gamma)	5.05E+06	
Toxaphene	5.97E+06	

VOCs & Semi-VOCs**ug/g****ug/g**

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

= variables requiring input

The relationship for predicting fugitive dust emissions during topsoil transportation by scraper is based on the silt content of the soil and the mean scraper weight.

DESCRIPTION:

TOPSOIL TRANSPORTATION BY SCRAPER -- ZONE A

For Respirable Fines <=15um EHE(kg/VKT)=2.2E-6*(s)^1.4*(W)^2.5 (note 1)		
Variable	Unit	Parameter
A, Area Subject to Topsoil Removal	m^2	29540
D, Depth of Topsoil Removal	m	0.3
DT, Bulk Density of Soil	Mg/m^3	1.5
V, Volume of Topsoil to be Removed (Transported)	m^3	8862
T, Total Period of Transporting	hr	317
Total Number of Round Trips (Assumes Scraper Cap.=10.7m^3)		952
s, Silt Content	%	84
W, Mean Scraper Weight	Mg	37.5
RT, Round Trip Distance	km	1.6
MT, Total Mass of Topsoil Transported	Mg	13293
VOC Total	g	0
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/VKT	8.73E+00
Non-Radionuclide (solids) Emission Rate	g/s	1.16E-05
Radionuclide Emission Rate (note 4)	pCi/s	2.34E+01
VOCs Emission Rate	g/s	0.00E+00

Turner X/Q		
Contaminant Dispersion	Unit	Parameter
Q1, Emission Rate - Non-Radionuclides	g/sec.	1.16E-05
Q2, Emission Rate - Radionuclides	pCi/sec.	2.34E+01
Q3, Emission Rate - VOCs	g/sec.	0.00E+00
Pi		3.14
Signa y	m	110
Signa z	m	43
Wind speed	m/sec	4.7
Contaminant Concentrations at Fence/line		
Non-Radionuclides	mg/m^3	1.67E-07
Radionuclides	pCi/m^3	3.35E-04
VOCs	mg/m^3	0.00E+00
Initial Concentrations of Contaminants in Soils at Source		
Radionuclides (pCi/g)		1.00E+00
Non-Rad's (ug/g or ppm)		1.00E+00
VOCs (ug/g or ppm)		0.00E+00

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

Note 1: Reference Memorandum from Tom Tishnie, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
Note 2: VOCs emissions are assumed to be negligible for this activity.
Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

TOPSOIL TRANSPORTATION BY SCRAPPER - ZONE A

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	3.35E-04
Intake/Exposure Period	pCi	2.94E+00

EPA L.E.C.R.

Uranium 233 & 234	8E-08
Uranium 235	7E-08
Uranium 238	7E-08
Americium 241	1E-07
Plutonium 239 & 240	1E-07
Tritium (gas)**	2E-13
Strontium 89	9E-12
Strontium 90	2E-10
Cesium 137	1E-10
Radium 226	9E-09
Radium 228	2E-09

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	1.67E-07
Intake/Exposure Period	mg	1.46E-03
Carcinogen Dose Rate	mg/kg/day	8.17E-10
Non-Carc. Dose Rate	mg/kg/day	1.14E-08

EPA L.E.C.R.

Arsenic	4E-08
Beryllium	7E-09
Cadmium	5E-09
Chromium VI	3E-09
a-Hexachlorocyclohexane	5E-09
B-Hexachlorocyclohexane	1E-09
Heptachlor	4E-09
Heptachlor Epoxide	7E-09
Aldrin	1E-08
Dieldrin	1E-09
DDT	3E-10
Chlordane (alpha, gamma)	1E-09
Toxaphene	9E-10

Hazard Quotient

Barium	1E-05
Chromium III	2E-03
Chromium VI	2E-03
Manganese	1E-04
Mercury	1E-04

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	0.00E+00
Intake/Exposure Period	mg	0.00E+00
Carcinogen Dose Rate	mg/kg/day	0.00E+00
Non-Carc. Dose Rate	mg/kg/day	0.00E+00

EPA L.E.C.R.

Chloroform	0E+00
Carbon Tetrachloride	0E+00
Benzene	0E+00
Dichloromethane	0E+00
1,2-Dichloroethane	0E+00
1,1-Dichloroethene	0E+00
1,3-Dichloropropene	0E+00
1,1,2-Trichloroethane	0E+00
Bromoform	0E+00
Tetrachloroethene	0E+00
Styrene	0E+00
Vinyl Chloride	0E+00
1,2-Dichloroethane	0E+00
1,2-Dichloropropane	0E+00
1,1,2,2-Tetrachloroethane	0E+00
2-Chloroethyl Ether	0E+00
Hexachlorethane	0E+00
Hexachlorobutadiene	0E+00
2,4,6-Trichlorophenol	0E+00
Hexachlorobenzene	0E+00

Hazard Quotient

1,1,1-Trichloroethane	0E+00
Toluene	0E+00
Dichloromethane	0E+00
Xylenes	0E+00
MEK	0E+00
Bromomethane	0E+00
Carbon Disulfide	0E+00
1,1-Dichloroethane	0E+00
Vinyl Acetate	0E+00
1,3-Dichloropropene	0E+00
Chlorobenzene	0E+00
Ethylbenzene	0E+00
1,4-Dichlorobenzene	0E+00
1,2-Dichlorobenzene	0E+00
Nitrobenzene	0E+00
1,2,4-Trichlorobenzene	0E+00
Hexachlorocyclopentadiene	0E+00

TOPSOIL TRANSPORTATION BY SCRAPER - ZONE A
EPA Threshold Levels
L.E.C.R
Threshold Conc.
HI
Threshold Conc.
Radionuclides
pCi/g

Uranium 233 & 234	1.26E+01
Uranium 235	1.36E+01
Uranium 238	1.42E+01
Americium 241	8.51E+00
Plutonium 239 & 240	8.31E+00
Tritium (gas)**	4.37E+06
Strontium 89	1.17E+05
Strontium 90	6.08E+03
Cesium 137	6.95E+03
Radium 226	1.14E+02
Radium 228	5.24E+02

Non-Radionuclides
ug/g
ug/g

Arsenic	2.45E+01	
Barium		8.74E+03
Beryllium	1.46E+02	
Cadmium	2.01E+02	
Chromium III		4.98E+01
Chromium VI	2.99E+02	4.98E+01
Manganese		9.97E+02
Mercury		7.52E+02
Hexachlorocyclohexane (alpha)	1.94E+02	
Hexachlorocyclohexane (beta)	6.80E+02	
Heptachlor	2.72E+02	
Heptachlor Epoxide	1.34E+02	
Aldrin	7.20E+01	
Dieldrin	7.65E+02	
DDT	3.60E+03	
Chlordane (alpha, gamma)	9.41E+02	
Toxaphene	1.11E+03	

VOCs & Semi-VOCs
ug/g
ug/g

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

= variables requiring input

DESCRIPTION: The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

MAJOR EXCAVATION BY FRONT-SHOVEL EXCAVATOR (BATCH DROP) - ZONE A

For Reptable Fines <=15um, K = 0.48

$$EHE(kg/Mg) = K(0.0009)[(d/5)(U/2.2)(H/1.5)](M/2)^{-2}(Y/4.6)^{-.33}$$
 (note 1)

Variable	Unit	Parameter
s, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	2
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	3.50
T, Total Period of Excavation	hr	900
V, Total Volume of Excavation	m ³	116000
DT, Bulk Density of Soil	Mg/m ³	1.5
MT, Total Mass of Soil	Mg	174600
VOC Total (note 2)	g	174600
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	5.40E-04
Non-Radionuclide (solids) Emission Rate	g/s	2.91E-08
Radionuclide Emission Rate (note 4)	pCi/s	0.00E+00
VOCs Emission Rate	g/s	5.39E-02

Note 1: Reference Memorandum from Tom Tishnic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal by scraper activity.
Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turner X/Q	Contaminant Dispersion	Unit	Parameter	Remark
Variable				
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.91E-08	Receptor @	
Q2, Emission Rate - Radionuclides	pCi/sec.	0.00E+00	1.64 km	
Q3, Emission Rate - VOCs	g/sec.	5.39E-02		
Pi		3.14		
Sigma y	m	110	Class Datability	
Sigma z	m	43	Class Datability	
Wind speed	m/sec	4.7		
Contaminant Concentrations at Fenceline				
Non-Radionuclides	mg/m ³	4.17E-10		
Radionuclides	pCi/m ³	0.00E+00		
VOCs	mg/m ³	7.72E-04		
Initial Concentrations of Contaminants in Soil at Source				
Radionuclides (pCi/g)		0.00E+00		
Non-Rad's (ug/g or ppm)		1.00E+00		
VOCs (ug/g or ppm)		1.00E+00		

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

MAJOR EXCAVATION BY FRONT SCHOVEL EXCAVATOR (BATCH DROP) - ZONE A

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	0.00E+00	
Intake/Exposure Period	pCi	0.00E+00	
EPA L.E.C.R.			
Uranium 233 & 234		0E+00	
Uranium 235		0E+00	
Uranium 238		0E+00	
Americium 241		0E+00	
Plutonium 239 & 240		0E+00	
Tritium (gas)**		0E+00	
Strontium 89		0E+00	
Strontium 90		0E+00	
Cesium 137		0E+00	
Radium 226		0E+00	
Radium 228		0E+00	
Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	4.17E-10	
Intake/Exposure Period	mg	3.63E-06	
Carcinogen Dose Rate	mg/kg/day	2.04E-12	
Non-Carc. Dose Rate	mg/kg/day	2.86E-11	
EPA L.E.C.R.			
Arsenic		1E-10	
Beryllium		2E-11	
Cadmium		1E-11	
Chromium VI		8E-12	
a-Hexachlorocyclohexane		1E-11	
B-Hexachlorocyclohexane		4E-12	
Heptachlor		9E-12	
Heptachlor Epoxide		2E-11	
Aldrin		3E-11	
Dieldrin		3E-12	
DDT		7E-13	
Chlordane (alpha, gamma)		3E-12	
Toxaphene		2E-12	
Hazard Quotient			
Barium		3E-08	
Chromium III		5E-06	
Chromium VI		5E-06	
Manganese		3E-07	
Mercury		3E-07	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	7.72E-04	
Intake/Exposure Period	mg	6.76E+00	
Carcinogen Dose Rate	mg/kg/day	3.78E-06	
Non-Carc. Dose Rate	mg/kg/day	5.29E-05	
EPA L.E.C.R.			
Chloroform		3E-07	
Carbon Tetrachloride		5E-07	
Benzene		1E-07	
Dichloromethane		8E-09	
1,2-Dichloroethane		3E-07	
1,1-Dichloroethene		5E-06	
1,3-Dichloropropene		5E-07	
1,1,2-Trichloroethane		2E-07	
Bromoform		1E-08	
Tetrachloroethene		7E-09	
Styrene		8E-09	
Vinyl Chloride		1E-07	
1,2-Dichloroethane		3E-07	
1,2-Dichloropropene		5E-07	
1,1,2,2-Tetrachloroethane		8E-07	
2-Chloroethyl Ether		4E-06	
Hexachlorethane		5E-08	
Hexachlorobutadiene		3E-07	
2,4,6-Trichlorophenol		4E-08	
Hexachlorobenzene		6E-06	
Hazard Quotient			
1,1,1-Trichloroethane		2E-05	
Toluene		9E-05	
Dichloromethane		6E-05	
Xylenes		6E-04	
MEK		6E-05	
Bromomethane		3E-03	
Carbon Disulfide		2E-02	
1,1-Dichloroethane		5E-05	
Vinyl Acetate		9E-04	
1,3-Dichloropropene		9E-03	
Chlorobenzene		1E-03	
Ethylbenzene		2E-04	
1,4-Dichlorobenzene		3E-04	
1,2-Dichlorobenzene		1E-04	
Nitrobenzene		9E-03	
1,2,4-Trichlorobenzene		2E-03	
Hexachlorocyclopentadiene		3E-01	

MAJOR EXCAVATION BY FRONT SHOVEL EXCAVATOR (BATCH DROP) - ZONE A

EPA Threshold Levels

L.E.C.R. HI
Threshold Conc. Threshold Conc.

Radionuclides

	pCi/g
Uranium 233 & 234	N/A
Uranium 235	N/A
Uranium 238	N/A
Americium 241	N/A
Plutonium 239 & 240	N/A
Tritium (gas)**	N/A
Strontium 89	N/A
Strontium 90	N/A
Cesium 137	N/A
Radium 226	N/A
Radium 228	N/A

Non-Radionuclides

	ug/g	ug/g
Arsenic	9.80E+03	
Barium		3.50E+06
Beryllium	5.83E+04	
Cadmium	8.03E+04	
Chromium III		1.99E+04
Chromium VI	1.20E+05	1.99E+04
Manganese		3.99E+05
Mercury		3.01E+05
Hexachlorocyclohexane (alpha)	7.78E+04	
Hexachlorocyclohexane (beta)	2.72E+05	
Heptachlor	1.09E+05	
Heptachlor Epoxide	5.38E+04	
Aldrin	2.88E+04	
Dieldrin	3.06E+05	
DDT	1.44E+06	
Chlordane (alpha, gamma)	3.77E+05	
Toxaphene	4.45E+05	

VOCs & Semi-VOCs

	ug/g	ug/g
Chloroform	3.27E+00	
1,1,1-Trichloroethane		5.67E+03
Carbon Tetrachloride	2.03E+00	
Benzene	8.82E+00	
Toluene		1.13E+03
Dichloromethane	1.32E+02	1.70E+03
Xylenes		1.70E+02
MEK		1.70E+03
1,2-Dichloroethane	2.91E+00	
Bromomethane		3.78E+01
Carbon Disulfide		5.67E+00
1,1-Dichloroethene	2.20E-01	
1,1-Dichloroethane		1.89E+03
Vinyl Acetate		1.13E+02
1,3-Dichloropropene	2.03E+00	1.13E+01
1,1,2-Trichloroethane	4.64E+00	
Bromoform	6.78E+01	
Tetrachloroethene	1.47E+02	
Chlorobenzene		9.45E+01
Ethylbenzene		5.67E+02
Styrene	1.32E+02	
Vinyl Chloride	9.12E+00	
1,2-Dichloroethane	2.91E+00	
1,2-Dichloropropane	2.03E+00	
1,1,2,2-Tetrachloroethane	1.32E+00	
2-Chloroethyl Ether	2.40E-01	
1,4-Dichlorobenzene		3.78E+02
1,2-Dichlorobenzene		7.56E+02
Nitrobenzene		1.13E+01
Hexachloroethane	1.89E+01	
1,2,4-Trichlorobenzene		5.67E+01
Hexachlorobutadiene	3.39E+00	
Hexachlorocyclopentadiene		3.78E-01
2,4,6-Trichlorophenol	2.40E+01	
Hexachlorobenzene	1.65E-01	

ATTACHMENT A.3.4
ZONE B CALCULATIONS

= variables requiring input

The equation for hole drilling predicts emissions on a per hole basis.

DESCRIPTION:

HOLE DRILLING - ZONE B

For Respirable Fines < =15um EHE(kg/hole) = 0.25 (note 1)		
Variable	Unit	Parameter
D, Depth of Hole	m	9
DI, Diameter of Hole	m	0.2
DT, Bulk Density of Soil	Mg/m ³	1.5
T, Total Period of Hole Drilling	hr	10
MT, Total Mass of Soil Removed	Mg	0.42
VOC Total (note 2)	g	0.42
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/hole	2.50E-01
Non-Radionuclide (solids) Emission Rate	g/s	6.94E-09
Radionuclide Emission Rate (note 4)	pCi/s	6.94E-03
VOCs Emission Rate	g/s	1.18E-05

Note 1: Reference Memorandum from Tom Tsalic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q	Parameter	Remark
Contaminant Dispersion		
Variable	Unit	
Q1, Emission Rate - Non-Radionuclides	g/sec.	6.94E-09 Receptor @ 2.9 km
Q2, Emission Rate - Radionuclides	pCi/sec.	6.94E-03
Q3, Emission Rate - VOCs	g/sec.	1.18E-05
P1		3.14
Sigma y	m	180 Class Distability
Sigma z	m	64 Class Distability
Wind speed	m/sec	4.7
Contaminant Concentrations at Fence/line		
Non-Radionuclides	mg/m ³	4.08E-11
Radionuclides	pCi/m ³	4.08E-08
VOCs	mg/m ³	6.93E-08
Initial Concentrations of Contaminants in Soil at Source		
Radionuclides (pCi/g)		1.00E+00
Non-Rad's (ug/g or ppm)		1.00E+00
VOCs (ug/g or ppm)		1.00E+00

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

HOLE DRILLING - ZONE B

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	4.08E-08	
Intake/Exposure Period		3.58E-04	
EPA L.E.C.R.			
Uranium 233 & 234		1E-11	
Uranium 235		9E-12	
Uranium 238		9E-12	
Americium 241		1E-11	
Plutonium 239 & 240		1E-11	
Tritium (g ₂)**		3E-17	
Strontium 89		1E-15	
Strontium 90		2E-14	
Cesium 137		2E-14	
Radium 226		1E-12	
Radium 228		2E-13	
Dose/Risk Estimates - Non - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	4.08E-11	
Intake/Exposure Period		3.58E-07	
Carcinogen Dose Rate	mg/kg/day	2.00E-13	
Non - Carc. Dose Rate	mg/kg/day	2.80E-12	
EPA L.E.C.R.			
Arsenic		1E-11	
Beryllium		2E-12	
Cadmium		1E-12	
Chromium VI		8E-13	
a - Hexachlorocyclohexane		1E-12	
B - Hexachlorocyclohexane		4E-13	
Heptachlor		9E-13	
Heptachlor Epoxide		2E-12	
Aldrin		3E-12	
Dieldrin		3E-13	
DDT		7E-14	
Chlordane (alpha, gamma)		3E-13	
Toxaphene		2E-13	
Hazard Quotient			
Barium		3E-09	
Chromium III		5E-07	
Chromium VI		5E-07	
Manganese		2E-08	
Mercury		3E-08	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	6.93E-08	
Intake/Exposure Period		6.07E-04	
Carcinogen Dose Rate	mg/kg/day	3.39E-10	
Non - Carc. Dose Rate	mg/kg/day	4.75E-09	
EPA L.E.C.R.			
Chloroform		3E-11	
Carbon Tetrachloride		4E-11	
1,1,1-Trichloroethane		1E-11	
1,2-Dichloroethane		7E-13	
1,1-Dichloroethene		3E-11	
1,3-Dichloropropene		4E-10	
1,1,2-Trichloroethane		4E-11	
Bromoform		2E-11	
Tetrachloroethene		1E-12	
Styrene		6E-13	
Vinyl Chloride		7E-13	
1,2-Dichloroethane		1E-11	
1,2-Dichloropropane		3E-11	
1,1,2,2-Tetrachloroethane		4E-11	
2-Chloroethyl Ether		7E-11	
Hexachloroethane		4E-10	
Hexachlorobutadiene		5E-12	
2,4,6-Trichlorophenol		3E-11	
Hexachlorobenzene		4E-12	
5E-10			
Hazard Quotient			
1,1,1-Trichloroethane		2E-09	
Toluene		8E-09	
Dichloromethane		5E-09	
Xylenes		5E-08	
MEK		5E-09	
Bromomethane		2E-07	
Carbon Disulfide		2E-06	
1,1-Dichloroethane		5E-09	
Vinyl Acetate		8E-08	
1,3-Dichloropropene		8E-07	
Chlorobenzene		9E-08	
Ethylbenzene		2E-08	
1,4-Dichlorobenzene		2E-08	
1,2-Dichlorobenzene		1E-08	
Nitrobenzene		8E-07	
1,2,4-Trichlorobenzene		2E-07	
Hexachlorocyclopentadiene		2E-05	

HOLE DRILLING - ZONE B
EPA Threshold Levels

L.E.C.R **HI**
Threshold Conc. **Threshold Conc.**

Radionuclides

pCi/g

Uranium 233 & 234	1.04E+05
Uranium 235	1.12E+05
Uranium 238	1.16E+05
Americium 241	6.99E+04
Plutonium 239 & 240	6.82E+04
Tritium (gas)**	3.58E+10
Strontium 89	9.64E+08
Strontium 90	4.99E+07
Cesium 137	5.70E+07
Radium 226	9.32E+05
Radium 228	4.30E+06

Non-Radionuclides

ug/g

ug/g

Arsenic	1.00E+05	
Barium		3.57E+07
Beryllium	5.95E+05	
Cadmium	8.19E+05	
Chromium III		2.04E+05
Chromium VI	1.22E+06	2.04E+05
Manganese		4.07E+06
Mercury		3.07E+06
Hexachlorocyclohexane (alpha)	7.93E+05	
Hexachlorocyclohexane (beta)	2.78E+06	
Heptachlor	1.11E+06	
Heptachlor Epoxide	5.49E+05	
Aldrin	2.94E+05	
Dieldrin	3.12E+06	
DDT	1.47E+07	
Chlordane (alpha, gamma)	3.84E+06	
Toxaphene	4.54E+06	

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform	3.64E+04	6.32E+07
1,1,1-Trichloroethane		
Carbon Tetrachloride	2.27E+04	
Benzene	9.83E+04	
Toluene		1.26E+07
Dichloromethane	1.47E+06	1.90E+07
Xylenes		1.90E+06
MEK		1.90E+07
1,2-Dichloroethane	3.24E+04	
Bromomethane		4.21E+05
Carbon Disulfide		6.32E+04
1,1-Dichloroethene	2.46E+03	
1,1-Dichloroethane		2.11E+07
Vinyl Acetate		1.26E+06
1,3-Dichloropropene	2.27E+04	1.26E+05
1,1,2-Trichloroethane	5.17E+04	
Bromoform	7.56E+05	
Tetrachloroethene	1.64E+06	
Chlorobenzene		1.05E+06
Ethylbenzene		6.32E+06
Styrene	1.47E+06	
Vinyl Chloride	1.02E+05	
1,2-Dichloroethane	3.24E+04	
1,2-Dichloropropane	2.27E+04	
1,1,2,2-Tetrachloroethane	1.47E+04	
2-Chloroethyl Ether	2.68E+03	
1,4-Dichlorobenzene		4.21E+06
1,2-Dichlorobenzene		8.42E+06
Nitrobenzene		1.26E+05
Hexachloroethane	2.11E+05	
1,2,4-Trichlorobenzene		6.32E+05
Hexachlorobutadiene	3.78E+04	
Hexachlorocyclopentadiene		4.21E+03
2,4,6-Trichlorophenol	2.68E+05	
Hexachlorobenzene	1.84E+03	

DESCRIPTION: The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation > = .254mm.

Vehicle Traffic - Light(10.Y.K.T.Dav) - Zone B.

For Respirable Fine < = 10um, K = 0.45
 $EHE(kg/VKT) = K(1.7/S(12)(S/48)(W/2.7)^{-1.7}(w/4)^{-1.5}(365-p)/365)$ (note 1)

Variable	Unit	Parameter
S, Silt Content	%	50.1
W, Mean Vehicle Speed	km/hr	16
w, Mean Vehicle Weight	Mg	2.7
P, Days with Prec. > = 0.254mm		4
T, Duration of Activity	hr	40
D, Total Vehicle Distance Travelled	km	10
VOC Total (note 2)		0.00

Emissions at Source: (note 3)

Particulate Emissions from Source	kg/hr	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/s	2.63E-07
Radionuclide Emission Rate (note 4)	pCi/s	2.63E-01
VOCs Emission Rate	g/s	0.00E+00

Note 1: Reference Memorandum from Tom Tistanic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984, Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs emissions are assumed to be negligible for this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-07	Receptor @ 2.9 km
Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E-01	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi		3.14	
Sigma y	m	182	Class Datability
Sigma z	m	64	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fence/line			
Non-Radionuclides	mg/m^3	1.53E-09	
Radionuclides	pCi/m^3	1.53E-06	
VOCs	mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

= variables requiring input

Vehicle Traffic - Light(10 VKT/Day) - Zone B

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	1.53E-06	
Intake/Exposure Period	pCi	1.34E-02	
EPA L.E.C.R.			
Uranium 233 & 234		4E-10	
Uranium 235		3E-10	
Uranium 238		3E-10	
Americium 241		5E-10	
Plutonium 239 & 240		6E-10	
Tritium (gaseous)		1E-15	
Strontium 89		4E-14	
Strontium 90		8E-13	
Cesium 137		7E-13	
Radium 226		4E-11	
Radium 228		9E-12	

Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	1.53E-09	
Intake/Exposure Period	mg	1.34E-05	
Carcinogen Dose Rate	mg/kg/day	7.50E-12	
Non-Carc. Dose Rate	mg/kg/day	1.05E-10	
EPA L.E.C.R.			
Arsenic		4E-10	
Beryllium		6E-11	
Cadmium		5E-11	
Chromium VI		3E-11	
a-Hexachlorocyclohexane		5E-11	
B-Hexachlorocyclohexane		1E-11	
Hepachlor		3E-11	
Heptachlor Epoxide		7E-11	
Aldrin		1E-10	
DDT		1E-11	
DDT		3E-12	
Chlordane (alpha, gamma)		1E-11	
Toxaphene		8E-12	
Hazard Quotient			
Barium		1E-07	
Chromium III		2E-05	
Chromium VI		2E-05	
Manganese		9E-07	
Mercury		1E-06	

Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non-Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA L.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2-Dichloroethane		0E+00	
1,1-Dichloroethene		0E+00	
1,3-Dichloropropene		0E+00	
1,1,2-Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2-Dichloroethane		0E+00	
1,2-Dichloropropane		0E+00	
1,1,2,2-Tetrachloroethane		0E+00	
2-Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6-Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1-Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1-Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3-Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4-Dichlorobenzene		0E+00	
1,2-Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4-Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

Vehicle Traffic - Light(10 VKT/Day) - Zone B
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	2.76E+03	
Uranium 235	2.98E+03	
Uranium 238	3.11E+03	
Americium 241	1.86E+03	
Plutonium 239 & 240	1.82E+03	
Tritium (gas)**	9.55E+08	
Strontium 89	2.57E+07	
Strontium 90	1.33E+06	
Cesium 137	1.52E+06	
Radium 226	2.48E+04	
Radium 228	1.15E+05	
Non-Radionuclides	ug/g	ug/g
Arsenic	2.67E+03	
Barium		9.52E+05
Beryllium	1.59E+04	
Cadmium	2.18E+04	
Chromium III		5.43E+03
Chromium VI	3.25E+04	5.43E+03
Manganese		1.09E+05
Mercury		8.19E+04
Hexachlorocyclohexane (alpha)	2.12E+04	
Hexachlorocyclohexane (beta)	7.40E+04	
Heptachlor	2.96E+04	
Heptachlor Epoxide	1.46E+04	
Aldrin	7.84E+03	
Dieldrin	8.33E+04	
DDT	3.92E+05	
Chlordane (alpha, gamma)	1.03E+05	
Toxaphene	1.21E+05	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

DESCRIPTION: The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation > = .254mm.

Vehicle Traffic = Heavy(100 VKT/Dav) - Zone B

For Reprable Fines < = 10um, K = 0.45

$$EHE(kg/KT) = K(1.7)(s/12)(S/48)(W/2.7)^{-.5}(365-p)/365 \text{ (note 1)}$$

Variable	Unit	Parameter
s, Silt Content	%	50.1
S, Mean Vehicle Speed	km/hr	16
W, Mean Vehicle Weight	Mg	2.7
p, Mean Number of Wheels		4
P, Days with Prec. > = 0.254mm	hr	40
T, Duration of Activity	km	10
D, Total Vehicle Distance Travelled		100
VOC Total (note 2)		0.00
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/s	2.63E-06
Radionuclide Emission Rate (note 4)	pCi/s	2.63E+00
VOCs Emission Rate	g/s	0.00E+00

Note 1: Reference Memorandum from Tom Tistanic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs emissions are assumed to be negligible for this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/O	Contaminant Dispersion Variable	Unit	Parameter	Remark
	-----	-----	-----	-----
	O1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-06	Receptor @ 2.9 km
	Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E+00	
	Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi		m	3.14	
Sigma y		m	182	Class Datability
Sigma z		m	64	Class Datability
Wind speed		m/sec	4.7	
Contaminant Concentrations at Fenceline				
Non-Radionuclides		mg/m ³	1.53E-08	
Radionuclides		pCi/m ³	1.53E-05	
VOCs		mg/m ³	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source				
	Radionuclides (pCi/g)		1.00E+00	
	Non-Rad's (ug/g or ppm)		1.00E+00	
	VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

= variables requiring input

Vehicle Traffic - Heavy(100 VKT/Day) - Zone B
Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	1.53E-05	
Intake/Exposure Period		1.34E-01	
EPA L.E.C.R.			
Uranium 233 & 234		4E-09	
Uranium 235		3E-09	
Uranium 238		3E-09	
Americium 241		5E-09	
Plutonium 239 & 240		6E-09	
Tritium (gas)**		1E-14	
Strontium 89		4E-13	
Strontium 90		8E-12	
Cesium 137		7E-12	
Radium 226		4E-10	
Radium 228		9E-11	

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	1.53E-08	
Intake/Exposure Period	mg	1.34E-04	
Carcinogen Dose Rate	mg/kg/day	7.50E-11	
Non-Carc. Dose Rate	mg/kg/day	1.05E-09	
EPA L.E.C.R.			
Arsenic		4E-09	
Beryllium		6E-10	
Cadmium		5E-10	
Chromium VI		3E-10	
a-Hexachlorocyclohexane		5E-10	
B-Hexachlorocyclohexane		1E-10	
Heptachlor		3E-10	
Heptachlor Epoxide		7E-10	
Aldrin		1E-09	
Dieldrin		1E-10	
DDT		3E-11	
Chlordane (alpha, gamma)		1E-10	
Toxaphene		8E-11	
Hazard Quotient			
Barium		1E-06	
Chromium III		2E-04	
Chromium VI		2E-04	
Manganese		9E-06	
Mercury		1E-05	

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non-Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA L.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2-Dichloroethane		0E+00	
1,1-Dichloroethene		0E+00	
1,3-Dichloropropene		0E+00	
1,1,2-Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2-Dichloroethane		0E+00	
1,2-Dichloropropane		0E+00	
1,1,2,2-Tetrachloroethane		0E+00	
2-Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6-Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1-Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1-Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3-Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4-Dichlorobenzene		0E+00	
1,2-Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4-Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

Vehicle Traffic - Heavy(100 VKT/Day) - Zone B
BPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	2.76E+02	
Uranium 235	2.98E+02	
Uranium 238	3.11E+02	
Americium 241	1.86E+02	
Plutonium 239 & 240	1.82E+02	
Tritium (gas)**	9.55E+07	
Strontium 89	2.57E+06	
Strontium 90	1.33E+05	
Cesium 137	1.52E+05	
Radium 226	2.48E+03	
Radium 228	1.15E+04	
Non-Radionuclides	ug/g	ug/g
Arsenic	2.67E+02	
Barium		9.52E+04
Beryllium	1.59E+03	
Cadmium	2.18E+03	
Chromium III		5.43E+02
Chromium VI	3.25E+03	5.43E+02
Manganese		1.09E+04
Mercury		8.19E+03
Hexachlorocyclohexane (alpha)	2.12E+03	
Hexachlorocyclohexane (beta)	7.40E+03	
Heptachlor	2.96E+03	
Heptachlor Epoxide	1.46E+03	
Aldrin	7.84E+02	
Dieldrin	8.33E+03	
DDT	3.92E+04	
Chlordane (alpha, gamma)	1.03E+04	
Toxaphene	1.21E+04	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

= variables requiring input

The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

DESCRIPTION:

BATCH DROP CALCULATION - TEST PUTS - ZONE B

For Respirable Fines < 15um, K = 0.48
$$EHF(g/Mg) = K(0.0009)[(a/5)(U/2.2)(H/1.5)]^{(M/2)} \wedge 2(Y/4.6) \wedge .33] \text{ (note 1)}$$

Variable	Unit	Parameter
s, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	1
M, Moisture Content	%	10
Y, Bucket Capacity	m^3	0.25
T, Duration of Activity	hr	10
D, Depth of Excavation	m	1.22
V, Volume of Excavation	m^3	3.95
DT, Bulk Density of Soil	Mg/m^3	1.50
MT, Total Mass of Soil/Pit	Mg	5.92
VOC Total (note 2)	g	5.9
Assuming one pit constructed per day for five years gives a total number of pits equal to:		1825
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	6.43E-04
Non-Radionuclide (solids) Emission Rate	g/h	1.06E-10
Radionuclide Emission Rate (note 4)	pCi/h	1.32E-05
VOCs Emission Rate	g/h	1.65E-04

Note 1: Reference Memorandum from Tom Twinn, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q	Unit	Parameter	Remark
Contaminant Dispersion			
Q1, Emission Rate - Non-Radionuclides	g/sec.	1.06E-10	Receptor @ 2.9 km
Q2, Emission Rate - Radionuclides	pCi/sec.	1.32E-05	
Q3, Emission Rate - VOCs	g/sec.	1.65E-04	
Pi		3.14	
Sigma y	m	182	Class Datability
Sigma z	m	64	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fence/line			
Non-Radionuclides	mg/m^3	6.15E-13	
Radionuclides	pCi/m^3	7.67E-11	
VOCs	mg/m^3	9.57E-07	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

BATCH DROP CALCULATION - TEST FITS - ZONE B

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	7.67E-11	
Intake/Exposure Period	pCi	6.72E-07	
EPA L.E.C.R.			
Uranium 233 & 234		2E-14	
Uranium 235		2E-14	
Uranium 238		2E-14	
Americium 241		3E-14	
Plutonium 239 & 240		3E-14	
Tritium (gas)**		5E-20	
Strontium 89		2E-18	
Strontium 90		4E-17	
Cesium 137		3E-17	
Radium 226		2E-15	
Radium 228		4E-16	
EPA L.E.C.R.			
Arsenic		2E-13	
Beryllium		3E-14	
Cadmium		2E-14	
Chromium VI		1E-14	
a - Hexachlorocyclohexane		2E-14	
B - Hexachlorocyclohexane		5E-15	
Heptachlor		1E-14	
Heptachlor Epoxide		3E-14	
Aldrin		5E-14	
Dieldrin		5E-15	
DDT		1E-15	
Chlordane (alpha, gamma)		4E-15	
Toxaphene		3E-15	
Hazard Quotient			
Barium		4E-11	
Chromium III		7E-09	
Chromium VI		7E-09	
Manganese		4E-10	
Mercury		5E-10	
Dose/Risk Estimates - Non - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	6.15E-13	
Intake/Exposure Period	mg	5.39E-09	
Carcinogen Dose Rate	mg/kg/day	3.01E-15	
Non - Carc. Dose Rate	mg/kg/day	4.22E-14	
EPA L.E.C.R.			
Chloroform		4E-10	
Carbon Tetrachloride		6E-10	
Benzene		1E-10	
Dichloromethane		9E-12	
1,2-Dichloroethane		4E-10	
1,1-Dichloroethene		6E-09	
1,3-Dichloropropene		6E-10	
1,1,2-Trichloroethane		3E-10	
Bromoform		2E-11	
Tetrachloroethene		8E-12	
Styrene		9E-12	
Vinyl Chloride		1E-10	
1,2-Dichloroethane		4E-10	
1,2-Dichloropropane		6E-10	
1,1,2,2-Tetrachloroethane		9E-10	
2-Chloroethyl Ether		5E-09	
Hexachloroethane		7E-11	
Hexachlorobutadiene		4E-10	
2,4,6-Trichlorophenol		5E-11	
Hexachlorobenzene		8E-09	
Hazard Quotient			
1,1,1-Trichloroethane		2E-08	
Toluene		1E-07	
Dichloromethane		7E-08	
Xylenes		7E-07	
MEK		7E-08	
Bromomethane		3E-06	
Carbon Disulfide		2E-05	
1,1-Dichloroethane		7E-08	
Vinyl Acetate		1E-06	
1,3-Dichloropropene		1E-05	
Chlorobenzene		1E-06	
Ethylbenzene		2E-07	
1,4-Dichlorobenzene		3E-07	
1,2-Dichlorobenzene		2E-07	
Nitrobenzene		1E-05	
1,2,4-Trichlorobenzene		2E-06	
Hexachlorocyclopentadiene		3E-04	

Dose/Risk Estimates - VOCs

BATCH DROP CALCULATION - TEST PITS - ZONE B		
BPA Threshold Levels	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	5.51E+07	
Uranium 235	5.96E+07	
Uranium 238	6.20E+07	
Americium 241	3.72E+07	
Plutonium 239 & 240	3.63E+07	
Tritium (gas)**	1.91E+13	
Strontium 89	5.13E+11	
Strontium 90	2.66E+10	
Cesium 137	3.04E+10	
Radium 226	4.96E+08	
Radium 228	2.29E+09	
Non-Radionuclides	ug/g	ug/g
Arsenic	6.64E+06	
Barium		2.37E+09
Beryllium	3.95E+07	
Cadmium	5.44E+07	
Chromium III		1.35E+07
Chromium VI	8.09E+07	1.35E+07
Manganese		2.70E+08
Mercury		2.04E+08
Hexachlorocyclohexane (alpha)	5.27E+07	
Hexachlorocyclohexane (beta)	1.84E+08	
Heptachlor	7.37E+07	
Heptachlor Epoxide	3.65E+07	
Aldrin	1.95E+07	
Dieldrin	2.07E+08	
DDT	9.76E+08	
Chlordane (alpha, gamma)	2.55E+08	
Toxaphene	3.02E+08	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	2.63E+03	
1,1,1-Trichloroethane		4.57E+06
Carbon Tetrachloride	1.64E+03	
Benzene	7.11E+03	
Toluene		9.14E+05
Dichloromethane	1.07E+05	1.37E+06
Xylenes		1.37E+05
MEK		1.37E+06
1,2-Dichloroethane	2.34E+03	
Bromomethane		3.05E+04
Carbon Disulfide		4.57E+03
1,1-Dichloroethene	1.78E+02	
1,1-Dichloroethane		1.52E+06
Vinyl Acetate		9.14E+04
1,3-Dichloropropene	1.64E+03	9.14E+03
1,1,2-Trichloroethane	3.74E+03	
Bromoform	5.47E+04	
Tetrachloroethene	1.18E+05	
Chlorobenzene		7.62E+04
Ethylbenzene		4.57E+05
Styrene	1.07E+05	
Vinyl Chloride	7.35E+03	
1,2-Dichloroethane	2.34E+03	
1,2-Dichloropropane	1.64E+03	
1,1,2,2-Tetrachloroethane	1.07E+03	
2-Chloroethyl Ether	1.94E+02	
1,4-Dichlorobenzene		3.05E+05
1,2-Dichlorobenzene		6.09E+05
Nitrobenzene		9.14E+03
Hexachloroethane	1.52E+04	
1,2,4-Trichlorobenzene		4.57E+04
Hexachlorobutadiene	2.73E+03	
Hexachlorocyclopentadiene		3.05E+02
2,4,6-Trichlorophenol	1.94E+04	
Hexachlorobenzene	1.33E+02	

DESCRIPTION:

The relationship for predicting fugitive dust emissions during topsoil removal by scraper is on a per mass unit basis of soil removed.

variables requiring input

TOPSOIL REMOVED BY SCRAPER - ZONE B

For Respirable Fines < = 15um EHE(kg/Mg) = 0.019kg/Mg of Soil Removed (note 1)		
Variable	Unit	Parameter
A, Area Subject to Topsoil Removal	m ²	29540
D, Depth of Topsoil Removal	m	0.3
DT, Bulk Density of Soil	Mg/m ³	1.5
V, Volume of Topsoil to be Removed	m ³	8862
T, Total Period of Removal	hr	317
MT, Total Mass of Topsoil Removed	Mg	13293
VOC Total (note 2)	g	13293
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	1.90E-02
Non-Radionuclide (soils) Emission Rate	g/h	2.21E-07
Radionuclide Emission Rate (note 4)	pCi/s	1.10E-01
VOCs Emission Rate	g/h	1.16E-02

Variable	Unit	Parameter	Remark
Contaminant Dispersion			
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.21E-07	Receptor @
Q2, Emission Rate - Radionuclides	pCi/sec.	1.10E-01	2.9 km
Q3, Emission Rate - VOCs	g/sec.	1.16E-02	
Pi		3.14	
Sigma y	m	182	Class Datability
Sigma z	m	64	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m ³	1.29E-09	
Radionuclides	pCi/m ³	6.43E-07	
VOCs	mg/m ³	6.77E-05	
Initial Concentrations of Contaminants in Soils at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Note 1: Reference Memorandum from Tom Tistanic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984, Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

TOPSOIL REMOVED BY SCRAPER - ZONE B

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	6.43E-07
Intake/Exposure Period	pCi	5.63E-03
EPA L.E.C.R.		
Uranium 233 & 234		2E-10
Uranium 235		1E-10
Uranium 238		1E-10
Americium 241		2E-10
Plutonium 239 & 240		2E-10
Tritium (gas)**		4E-16
Strontium 89		2E-14
Strontium 90		3E-13
Cesium 137		3E-13
Radium 226		2E-11
Radium 228		4E-12
EPA L.E.C.R.		
Arsonic		3E-10
Beryllium		5E-11
Cadmium		4E-11
Chromium VI		3E-11
a-Hexachlorocyclohexane		4E-11
B-Hexachlorocyclohexane		1E-11
Heptachlor		3E-11
Heptachlor Epoxide		6E-11
Aldrin		1E-10
Dieldrin		1E-11
DDT		2E-12
Chlordane (alpha, gamma)		8E-12
Toxaphene		7E-12
Hazard Quotient		
Barium		9E-08
Chromium III		2E-05
Chromium VI		2E-05
Manganese		8E-07
Mercury		1E-06

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	1.29E-09
Intake/Exposure Period	mg	1.13E-05
Carcinogen Dose Rate	mg/kg/day	6.30E-12
Non-Carc. Dose Rate	mg/kg/day	8.81E-11
EPA L.E.C.R.		
Arsonic		3E-10
Beryllium		5E-11
Cadmium		4E-11
Chromium VI		3E-11
a-Hexachlorocyclohexane		4E-11
B-Hexachlorocyclohexane		1E-11
Heptachlor		3E-11
Heptachlor Epoxide		6E-11
Aldrin		1E-10
Dieldrin		1E-11
DDT		2E-12
Chlordane (alpha, gamma)		8E-12
Toxaphene		7E-12
Hazard Quotient		
Barium		9E-08
Chromium III		2E-05
Chromium VI		2E-05
Manganese		8E-07
Mercury		1E-06

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	6.77E-05
Intake/Exposure Period	mg	5.93E-01
Carcinogen Dose Rate	mg/kg/day	3.31E-07
Non-Carc. Dose Rate	mg/kg/day	4.64E-06
EPA L.E.C.R.		
Chloroform		3E-08
Carbon Tetrachloride		4E-08
Benzene		1E-08
Dichloromethane		7E-10
1,2-Dichloroethane		3E-08
1,1-Dichloroethene		4E-07
1,3-Dichloropropene		4E-08
1,1,2-Trichloroethane		2E-08
Bromoform		1E-09
Tetrachloroethene		6E-10
Styrene		7E-10
Vinyl Chloride		1E-08
1,2-Dichloroethane		3E-08
1,2-Dichloropropane		4E-08
1,1,2,2-Tetrachloroethane		7E-08
2-Chloroethyl Ether		4E-07
Hexachlorethane		5E-09
Hexachlorobutadiene		3E-08
2,4,6-Trichlorophenol		4E-09
Hexachlorobenzene		5E-07
Hazard Quotient		
1,1,1-Trichloroethane		2E-06
Toluene		8E-06
Dichloromethane		5E-06
Xylenes		5E-05
MEK		5E-06
Bromomethane		2E-04
Carbon Disulfide		2E-03
1,1-Dichloroethane		5E-06
Vinyl Acetate		8E-05
1,3-Dichloropropene		9E-05
Chlorobenzene		2E-05
Ethylbenzene		2E-05
1,4-Dichlorobenzene		1E-05
1,2-Dichlorobenzene		8E-04
Nitrobenzene		2E-04
1,2,4-Trichlorobenzene		2E-04
Hexachlorocyclopentadiene		2E-02

TOPSOIL REMOVED BY SCRAPER - ZONE B
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides		
	pCi/g	
Uranium 233 & 234	6.58E+03	
Uranium 235	7.10E+03	
Uranium 238	7.40E+03	
Americium 241	4.44E+03	
Plutonium 239 & 240	4.33E+03	
Tritium (gas)**	2.28E+09	
Strontium 89	6.12E+07	
Strontium 90	3.17E+06	
Cesium 137	3.62E+06	
Radium 226	5.92E+04	
Radium 228	2.73E+05	
Non-Radionuclides		
	ug/g	ug/g
Arsenic	3.18E+03	
Barium		1.13E+06
Beryllium	1.89E+04	
Cadmium	2.60E+04	
Chromium III		6.47E+03
Chromium VI	3.87E+04	6.47E+03
Manganese		1.29E+05
Mercury		9.76E+04
Hexachlorocyclohexane (alpha)	2.52E+04	
Hexachlorocyclohexane (beta)	8.82E+04	
Heptachlor	3.53E+04	
Heptachlor Epoxide	1.75E+04	
Aldrin	9.34E+03	
Dieldrin	9.93E+04	
DDT	4.67E+05	
Chlordane (alpha, gamma)	1.22E+05	
Toxaphene	1.44E+05	
VOCs & Semi-VOCs		
	ug/g	ug/g
Chloroform	3.73E+01	
1,1,1-Trichloroethane		6.47E+04
Carbon Tetrachloride	2.32E+01	
Benzene	1.01E+02	
Toluene		1.29E+04
Dichloromethane	1.51E+03	1.94E+04
Xylenes		1.94E+03
MEK		1.94E+04
1,2-Dichloroethane	3.32E+01	
Bromomethane		4.31E+02
Carbon Disulfide		6.47E+01
1,1-Dichloroethene	2.51E+00	
1,1-Dichloroethane		2.16E+04
Vinyl Acetate		1.29E+03
1,3-Dichloropropene	2.32E+01	1.29E+02
1,1,2-Trichloroethane	5.29E+01	
Bromoform	7.74E+02	
Tetrachloroethene	1.68E+03	
Chlorobenzene		1.08E+03
Ethylbenzene		6.47E+03
Styrene	1.51E+03	
Vinyl Chloride	1.04E+02	
1,2-Dichloroethane	3.32E+01	
1,2-Dichloropropane	2.32E+01	
1,1,2,2-Tetrachloroethane	1.51E+01	
2-Chloroethyl Ether	2.74E+00	
1,4-Dichlorobenzene		4.31E+03
1,2-Dichlorobenzene		8.62E+03
Nitrobenzene		1.29E+02
Hexachloroethane	2.16E+02	
1,2,4-Trichlorobenzene		6.47E+02
Hexachlorobutadiene	3.87E+01	
Hexachlorocyclopentadiene		4.31E+00
2,4,6-Trichlorophenol	2.74E+02	
Hexachlorobenzene	1.89E+00	

DESCRIPTION: The equation for batch drop operations predicts emission factors based on particle size, silt content, windspeed, drop height, moisture content, and dumping device capacity.

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE B

For Respirable Fines < =15um, K = 0.48
 $EHE(kg/Mg) = K(0.0009)((s/5)(U/2.2)(H/1.5))((M/2) \wedge 2(Y/4.6) \wedge .33)$ (note 1)

Variable	Unit	Parameter
s, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	1
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	10.70
T, Total Period of Unloading	hr	317
D, Depth of Excavation	m	0.30
A, Area of Topsoil Removed	m ²	29540
DT, Bulk Density of Soil	Mg/m ³	1.50
MT, Total Mass of Topsoil	Mg	13293
VOC Total (note 2)	g	0.0

Emissions at Source: (note 3)

Particulate Emissions from Source	kg/Mg	1.87E-04
Non-Radionuclide (solids) Emission Rate	g/s	2.17E-09
Radionuclide Emission Rate (note 4)	pCi/s	1.09E-03
VOCs Emission Rate	g/s	0.00E+00

Note 1: Reference Memorandum from Tom Tiatin, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal by scraper activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turner X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.17E-09	Receptor @ 2.9 km
Q2, Emission Rate - Radionuclides	pCi/sec.	1.09E-03	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi		3.14	
Sigma y	m	182	Class Datability
Sigma z	m	64	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m ³	1.26E-11	
Radionuclides	pCi/m ³	6.31E-09	
VOCs	mg/m ³	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		0.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

= variables requiring input

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE B

Dose/Risk Estimates - Radionuclides				Dose/Risk Estimates - Non - Radionuclides				Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter		Variable	Unit	Parameter		Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2		Intake Rate	m ³ /hr	1.2		Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10		Intake Duration	hr/day	10		Intake Duration	hr/day	10	
Exposure Period	Days	1825		Exposure Period	Days	1825		Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4		Fract. Leeward Wind Factor		0.4		Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	6.31E-09		Intake Concentration	mg/m ³	1.26E-11		Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	pCi	5.53E-05		Intake/Exposure Period	mg	1.11E-07		Intake/Exposure Period	mg	0.00E+00	
				Carcinogen Dose Rate	mg/kg/day	6.19E-14		Carcinogen Dose Rate	mg/kg/day	0.00E+00	
				Non - Carc. Dose Rate	mg/kg/day	8.66E-13		Non - Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA I.E.C.R.				EPA I.E.C.R.				EPA I.E.C.R.			
Uranium 233 & 234		1E-12		Arsenic		3E-12		Chloroform		0E+00	
Uranium 235		1E-12		Beryllium		5E-13		Carbon Tetrachloride		0E+00	
Uranium 238		1E-12		Cadmium		4E-13		Benzene		0E+00	
Americium 241		2E-12		Chromium VI		3E-13		Dichloromethane		0E+00	
Plutonium 239 & 240		2E-12		a - Hexachlorocyclohexane		4E-13		1,2 - Dichloroethane		0E+00	
Tritium (gas)**		4E-18		B - Hexachlorocyclohexane		1E-13		1,1 - Dichloroethene		0E+00	
Strontium 89		2E-16		Heptachlor		3E-13		1,3 - Dichloropropene		0E+00	
Strontium 90		3E-15		Heptachlor Epoxide		6E-13		1,1,2 - Trichloroethane		0E+00	
Cesium 137		3E-15		Aldrin		1E-12		Bromoform		0E+00	
Radium 226		2E-13		Dieldrin		1E-13		Tetrachloroethene		0E+00	
Radium 228		4E-14		DDT		2E-14		Styrene		0E+00	
				Chlordane (alpha, gamma)		8E-14		Vinyl Chloride		0E+00	
				Toxaphene		7E-14		1,2 - Dichloropropane		0E+00	
EPA I.E.C.R.				Hazard Quotient				1,1,2,2 - Tetrachloroethane		0E+00	
				Barium		9E-10		2 - Chloroethyl Ether		0E+00	
				Chromium III		2E-07		Hexachloroethane		0E+00	
				Chromium VI		2E-07		Hexachlorobutadiene		0E+00	
				Manganese		8E-09		2,4,6 - Trichlorophenol		0E+00	
				Mercury		1E-08		Hexachlorobenzene		0E+00	
EPA I.E.C.R.				Hazard Quotient				Hazard Quotient			
								1,1,1 - Trichloroethane		0E+00	
								Toluene		0E+00	
								Dichloromethane		0E+00	
								Xylenes		0E+00	
								MEK		0E+00	
								Bromomethane		0E+00	
								Carbon Disulfide		0E+00	
								1,1 - Dichloroethane		0E+00	
								Vinyl Acetate		0E+00	
								1,3 - Dichloropropene		0E+00	
								Chlorobenzene		0E+00	
								Ethylbenzene		0E+00	
								1,4 - Dichlorobenzene		0E+00	
								1,2 - Dichlorobenzene		0E+00	
								Nitrobenzene		0E+00	
								1,2,4 - Trichlorobenzene		0E+00	
								Hexachlorocyclopentadiene		0E+00	

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE B
EPA Threshold Levels
**L.E.C.R
Threshold Conc.**
**HI
Threshold Conc.**
Radionuclides
pCi/g

Uranium 233 & 234	6.70E+05
Uranium 235	7.23E+05
Uranium 238	7.53E+05
Americium 241	4.52E+05
Plutonium 239 & 240	4.41E+05
Tritium (gas)**	2.32E+11
Strontium 89	6.23E+09
Strontium 90	3.23E+08
Cesium 137	3.69E+08
Radium 226	6.03E+06
Radium 228	2.78E+07

Non-Radionuclides
ug/g
ug/g

Arsenic	3.23E+05	
Barium		1.15E+08
Beryllium	1.92E+06	
Cadmium	2.65E+06	
Chromium III		6.58E+05
Chromium VI	3.94E+06	6.58E+05
Manganese		1.32E+07
Mercury		9.93E+06
Hexachlorocyclohexane (alpha)	2.57E+06	
Hexachlorocyclohexane (beta)	8.98E+06	
Heptachlor	3.59E+06	
Heptachlor Epoxide	1.78E+06	
Aldrin	9.51E+05	
Dieldrin	1.01E+07	
DDT	4.76E+07	
Chlordane (alpha, gamma)	1.24E+07	
Toxaphene	1.47E+07	

VOCs & Semi-VOCs
ug/g
ug/g

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

----- = variables requiring input

The relationship for predicting fugitive dust emissions during topsoil transportation by scraper is based on the silt content of the soil and the mean scraper weight.

DESCRIPTION: TOPSOIL TRANSPORTATION BY SCRAPER - ZONE B

For Replicable Fines < = 15um
EHE(kg/VKT)=2.2E-6*(e)^1.4*(W)^2.5 (note 1)

Variable	Unit	Parameter
A, Area Subject to Topsoil Removal	m^2	29540
D, Depth of Topsoil Removal	m	0.3
DT, Bulk Density of Soil	Mg/m^3	1.5
V, Volume of Topsoil to be Removed (Transported)	m^3	8862
T, Total Period of Transporting	hr	317
Total Number of Round Trips (Assumes Scraper Cap.=10.7m^3)	%	952
s, Silt Content	Mg	80
W, Mean Scraper Weight	kg	37.5
RT, Round Trip Distance	km	1.6
MT, Total Mass of Topsoil Transported	Mg	13293
VOC Total	g	0

Emissions at Source: (note 3)

Particulate Emissions from Source	kg/VKT	8.73E+00
Non-Radionuclide (solids) Emission Rate	g/s	1.16E-05
Radionuclide Emission Rate (note 4)	pCi/s	2.34E+01
VOC Emission Rate	g/s	0.00E+00

Turner X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	1.16E-05	Receptor @ 2.9 km
Q2, Emission Rate - Radionuclides	pCi/sec.	2.34E+01	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
P1		3.14	
Sigma y	m	182	Class D stability
Sigma z	m	64	Class D stability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m^3	6.77E-08	
Radionuclides	pCi/m^3	1.36E-04	
VOCs	mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		0.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

Note 1: Reference Memorandum from Tom Tisink, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs emissions are assumed to be negligible during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

TOPSOIL TRANSPORTATION BY SCRAPER - ZONE B

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	1.36E-04	
Intake/Exposure Period	pCi	1.19E+00	
EPA L.E.C.R.			
Uranium 233 & 234		3E-08	
Uranium 235		3E-08	
Uranium 238		3E-08	
Americium 241		5E-08	
Plutonium 239 & 240		5E-08	
Tritium (gas)**		9E-14	
Strontium 89		3E-12	
Strontium 90		7E-11	
Cesium 137		6E-11	
Radium 226		4E-09	
Radium 228		8E-10	
Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	6.77E-08	
Intake/Exposure Period	mg	5.93E-04	
Carcinogen Dose Rate	mg/kg/day	3.32E-10	
Non-Carc. Dose Rate	mg/kg/day	4.65E-09	
EPA L.E.C.R.			
Arsenic		2E-08	
Beryllium		3E-09	
Cadmium		2E-09	
Chromium VI		1E-09	
a-Hexachlorocyclohexane		2E-09	
B-Hexachlorocyclohexane		6E-10	
Heptachlor		1E-09	
Heptachlor Epoxide		3E-09	
Aldrin		6E-09	
Dieldrin		5E-10	
DDT		1E-10	
Chlordane (alpha, gamma)		4E-10	
Toxaphene		4E-10	
Hazard Quotient			
Barium		5E-06	
Chromium III		8E-04	
Chromium VI		8E-04	
Manganese		4E-05	
Mercury		5E-05	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non-Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA L.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2-Dichloroethane		0E+00	
1,1-Dichloroethene		0E+00	
1,3-Dichloropropene		0E+00	
1,1,2-Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2-Dichloroethane		0E+00	
1,2-Dichloropropane		0E+00	
1,1,2,2-Tetrachloroethane		0E+00	
2-Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6-Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1-Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1-Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3-Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4-Dichlorobenzene		0E+00	
1,2-Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4-Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

TOPSOIL TRANSPORTATION BY SCRAPER - ZONE B
EPA Threshold Levels
L.E.C.R
Threshold Conc.
HI
Threshold Conc.
Radionuclides
pCi/g

Uranium 233 & 234	3.11E+01
Uranium 235	3.35E+01
Uranium 238	3.49E+01
Americium 241	2.10E+01
Plutonium 239 & 240	2.05E+01
Tritium (gas)**	1.08E+07
Strontium 89	2.89E+05
Strontium 90	1.50E+04
Cesium 137	1.71E+04
Radium 226	2.80E+02
Radium 228	1.29E+03

Non-Radionuclides
ug/g
ug/g

Arsenic	6.03E+01	
Barium		2.15E+04
Beryllium	3.59E+02	
Cadmium	4.94E+02	
Chromium III		1.23E+02
Chromium VI	7.35E+02	1.23E+02
Manganese		2.45E+03
Mercury		1.85E+03
Hexachlorocyclohexane (alpha)	4.78E+02	
Hexachlorocyclohexane (beta)	1.67E+03	
Heptachlor	6.70E+02	
Heptachlor Epoxide	3.31E+02	
Aldrin	1.77E+02	
Dieldrin	1.88E+03	
DDT	8.86E+03	
Chlordane (alpha, gamma)	2.32E+03	
Toxaphene	2.74E+03	

VOCs & Semi-VOCs
ug/g
ug/g

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

DESCRIPTION: The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

MAJOR EXCAVATION BY FRONT-SHOVEL EXCAVATOR (BATCH DROP) - ZONE B

For Respirable Fines <=15um, K = 0.48

$$EHE(g/Mg) = K(0.0009)[(d/5)(U/2.2)(H/1.5)]/[(M/2) \wedge 2(Y/4.6) \wedge .33] \text{ (note 1)}$$

Variable	Unit	Parameter
s, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	2
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	3.50
T, Total Period of Excavation	hr	900
V, Total Volume of Excavation	m ³	116400
DT, Bulk Density of Soil	Mg/m ³	1.5
MT, Total Mass of Soil	Mg	174600
VOC Total (note 2)	g	174600
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	5.40E-04
Non-Radionuclide (solids) Emission Rate	g/s	2.91E-08
Radionuclide Emission Rate (note 4)	pCi/s	0.00E+00
VOCs Emission Rate	g/s	5.39E-02

Note 1: Reference Memorandum from Tom Taitnie, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q	Contaminant Dispersion Variable	Unit	Parameter	Remark
	Q1, Emission Rate - Non-Radionuclides	g/sec.	2.91E-08	Receptor @ 2.9 km
	Q2, Emission Rate - Radionuclides	pCi/sec.	0.00E+00	
	Q3, Emission Rate - VOCs	g/sec.	5.39E-02	
	Pi		3.14	
	Sigma y	m	182	Class D stability
	Sigma z	m	64	Class D stability
	Wind speed	m/sec	4.7	
	Contaminant Concentrations at Fence/line			
	Non-Radionuclides	mg/m ³	1.69E-10	
	Radionuclides	pCi/m ³	0.00E+00	
	VOCs	mg/m ³	3.13E-04	
	Initial Concentrations of Contaminants in Soil at Source			
	Radionuclides (pCi/g)		0.00E+00	
	Non-Rad's (ug/g or ppm)		1.00E+00	
	VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

- variables requiring input

MAJOR EXCAVATION BY FRONT SHOVEL EXCAVATOR (BATCH DROP) - ZONE B

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	0.00E+00	
Intake/Exposure Period	pCi	0.00E+00	
EPA L.E.C.R.			
Uranium 233 & 234		0E+00	
Uranium 235		0E+00	
Uranium 238		0E+00	
Americium 241		0E+00	
Plutonium 239 & 240		0E+00	
Tritium (gas)**		0E+00	
Strontium 89		0E+00	
Strontium 90		0E+00	
Cesium 137		0E+00	
Radium 226		0E+00	
Radium 228		0E+00	
Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	1.69E-10	
Intake/Exposure Period	mg	1.48E-06	
Carcinogen Dose Rate	mg/kg/day	8.29E-13	
Non-Carc. Dose Rate	mg/kg/day	1.16E-11	
EPA L.E.C.R.			
Arsenic		4E-11	
Beryllium		7E-12	
Cadmium		5E-12	
Chromium VI		3E-12	
a-Hexachlorocyclohexane		5E-12	
B-Hexachlorocyclohexane		1E-12	
Heptachlor		4E-12	
Heptachlor Epoxide		8E-12	
Aldrin		1E-11	
Dieldrin		1E-12	
DDT		3E-13	
Chlordane (alpha, gamma)		1E-12	
Toxaphene		9E-13	
Hazard Quotient			
Barium		1E-08	
Chromium III		2E-06	
Chromium VI		2E-06	
Manganese		1E-07	
Mercury		1E-07	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.13E-04	
Intake/Exposure Period	mg	2.75E+00	
Carcinogen Dose Rate	mg/kg/day	1.54E-06	
Non-Carc. Dose Rate	mg/kg/day	2.15E-05	
EPA L.E.C.R.			
Chloroform		1E-07	
Carbon Tetrachloride		2E-07	
Benzene		5E-08	
Dichloromethane		3E-09	
1,2-Dichloroethane		1E-07	
1,1-Dichloroethene		2E-06	
1,3-Dichloropropene		2E-07	
1,1,2-Trichloroethane		9E-08	
Bromoform		6E-09	
Tetrachloroethene		3E-09	
Styrene		3E-09	
Vinyl Chloride		4E-08	
1,2-Dichloroethane		1E-07	
1,2-Dichloropropane		2E-07	
1,1,2,2-Tetrachloroethane		3E-07	
2-Chloroethyl Ether		2E-06	
Hexachlorethane		2E-08	
Hexachlorobutadiene		1E-07	
2,4,6-Trichlorophenol		2E-08	
Hexachlorobenzene		2E-06	
Hazard Quotient			
1,1,1-Trichloroethane		7E-06	
Toluene		4E-05	
Dichloromethane		2E-05	
Xylenes		2E-04	
MEK		2E-05	
Bromomethane		1E-03	
Carbon Disulfide		7E-03	
1,1-Dichloroethane		2E-05	
Vinyl Acetate		4E-04	
1,3-Dichloropropene		4E-03	
Chlorobenzene		4E-04	
Ethylbenzene		7E-05	
1,4-Dichlorobenzene		1E-04	
1,2-Dichlorobenzene		5E-05	
Nitrobenzene		4E-03	
1,2,4-Trichlorobenzene		7E-04	
Hexachlorocyclopentadiene		1E-01	

MAJOR EXCAVATION BY FRONT SHOVEL EXCAVATOR (BATCH DROP) - ZONE B
BPA Threshold Levels

LECR **HI**
Threshold Conc. Threshold Conc.

Radionuclides

pCi/g

Uranium 233 & 234
Uranium 235
Uranium 238
Americium 241
Plutonium 239 & 240
Tritium (gas)**
Strontium 89
Strontium 90
Cesium 137
Radium 226
Radium 228

N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A
N/A

Non-Radionuclides

ug/g

ug/g

Arsenic
Barium
Beryllium
Cadmium
Chromium III
Chromium VI
Manganese
Mercury
Hexachlorocyclohexane (alpha)
Hexachlorocyclohexane (beta)
Heptachlor
Heptachlor Epoxide
Aldrin
Dieldrin
DDT
Chlordane (alpha, gamma)
Toxaphene

2.41E+04

1.44E+05
1.98E+05

2.94E+05

1.92E+05
6.70E+05
2.68E+05
1.33E+05
7.10E+04
7.54E+05
3.55E+06
9.28E+05
1.10E+06

8.62E+06

4.91E+04
4.91E+04
9.83E+05
7.41E+05

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform
1,1,1-Trichloroethane
Carbon Tetrachloride
Benzene
Toluene
Dichloromethane
Xylenes
MEK
1,2-Dichloroethane
Bromomethane
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
Vinyl Acetate
1,3-Dichloropropene
1,1,2-Trichloroethane
Bromoform
Tetrachloroethene
Chlorobenzene
Ethylbenzene
Styrene
Vinyl Chloride
1,2-Dichloroethane
1,2-Dichloropropane
1,1,2,2-Tetrachloroethane
2-Chloroethyl Ether
1,4-Dichlorobenzene
1,2-Dichlorobenzene
Nitrobenzene
Hexachloroethane
1,2,4-Trichlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
Hexachlorobenzene

8.04E+00

5.01E+00
2.17E+01

3.26E+02

7.16E+00

5.43E-01

5.01E+00
1.14E+01
1.67E+02
3.62E+02

3.26E+02
2.25E+01
7.16E+00
5.01E+00
3.26E+00
5.92E-01

4.65E+01
8.35E+00
5.92E+01
4.07E-01

1.40E+04

2.79E+03
4.19E+03
4.19E+02
4.19E+03

9.30E+01
1.40E+01

4.65E+03
2.79E+02
2.79E+01

2.33E+02
1.40E+03

9.30E+02
1.86E+03
2.79E+01

1.40E+02
9.30E-01

ATTACHMENT A.3.5
ZONE C CALCULATIONS

DESCRIPTION: The equation for hole drilling predicts emissions on a per hole basis. = variables requiring input

HOLE DRILLING - ZONE C

For Respirable Fines <=15um
EHE(kg/hole) = 0.25 (note 1)

Variable	Unit	Parameter
D, Depth of Hole	m	9
DI, Diameter of Hole	m	0.2
DT, Bulk Density of Soil	Mg/m ³	1.5
T, Total Period of Hole Drilling	hr	10
MT, Total Mass of Soil Removed	Mg	0.42
VOC Total (note 2)	g	0.42
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/hole	2.50E-01
Non-Radionuclide (solids) Emission Rate	g/h	6.94E-09
Radionuclide Emission Rate (note 4)	pCi/h	6.94E-03
VOCs Emission Rate	g/h	1.18E-05

Note 1: Reference Memorandum from Tom Tistanic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turner X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	6.94E-09	Receptor @
Q2, Emission Rate - Radionuclides	pCi/sec.	6.94E-03	4.4 km
Q3, Emission Rate - VOCs	g/sec.	1.18E-05	
Pi		3.14	
Sigma y	m	280	Class Detability
Sigma z	m	80	Class Detability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m ³	2.10E-11	
Radionuclides	pCi/m ³	2.10E-08	
VOCs	mg/m ³	3.56E-08	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

HOLE DRILLING - ZONE C

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	pCi/m ³	2.10E-08
Intake/Exposure Period	pCi	1.84E-04

EPA L.E.C.R.

Uranium 233 & 234	5E-12
Uranium 235	5E-12
Uranium 238	4E-12
Americium 241	7E-12
Plutonium 239 & 240	8E-12
Tritium (g _s)**	1E-17
Strontium 89	5E-16
Strontium 90	1E-14
Cesium 137	9E-15
Radium 226	6E-13
Radium 228	1E-13

Dose/Risk Estimates - Non - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	mg/m ³	2.10E-11
Intake/Exposure Period	mg	1.84E-07
Carcinogen Dose Rate	mg/kg/day	1.03E-13
Non - Carc. Dose Rate	mg/kg/day	1.44E-12

EPA L.E.C.R.

Arsenic	5E-12
Beryllium	9E-13
Cadmium	6E-13
Chromium VI	4E-13
a - Hexachlorocyclohexane	6E-13
B - Hexachlorocyclohexane	2E-13
Heptachlor	5E-13
Heptachlor Epoxide	9E-13
Aldrin	2E-12
Dieldrin	2E-13
DDT	3E-14
Chlordane (alpha, gamma)	1E-13
Toxaphene	1E-13

Hazard Quotient

Barium	1E-09
Chromium III	3E-07
Chromium VI	3E-07
Manganese	1E-08
Mercury	2E-08

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	mg/m ³	3.56E-08
Intake/Exposure Period	mg	3.12E-04
Carcinogen Dose Rate	mg/kg/day	1.74E-10
Non - Carc. Dose Rate	mg/kg/day	2.44E-09

EPA L.E.C.R.

Chloroform	1E-11
Carbon Tetrachloride	2E-11
Benzene	5E-12
Dichloromethane	3E-13
1,2-Dichloroethane	2E-11
1,1-Dichloroethene	2E-10
1,3-Dichloropropene	2E-11
1,1,2-Trichloroethane	1E-11
Bromoform	7E-13
Tetrachloroethene	3E-13
Styrene	3E-13
Vinyl Chloride	5E-12
1,2-Dichloroethane	2E-11
1,2-Dichloropropane	2E-11
1,1,2,2-Tetrachloroethane	3E-11
2-Chloroethyl Ether	2E-10
Hexachloroethane	2E-12
Hexachlorobutadiene	1E-11
2,4,6-Trichlorophenol	2E-12
Hexachlorobenzene	3E-10

Hazard Quotient

1,1,1-Trichloroethane	8E-10
Toluene	4E-09
Dichloromethane	3E-09
Xylenes	3E-08
MEK	3E-09
Bromomethane	1E-07
Carbon Disulfide	8E-07
1,1-Dichloroethane	2E-09
Vinyl Acetate	4E-08
1,3-Dichloropropene	4E-07
Chlorobenzene	5E-08
Ethylbenzene	8E-09
1,4-Dichlorobenzene	1E-08
1,2-Dichlorobenzene	6E-09
Nitrobenzene	4E-07
1,2,4-Trichlorobenzene	8E-08
Hexachlorocyclopentadiene	1E-05

HOLE DRILLING - ZONE C
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	2.01E+05	
Uranium 235	2.17E+05	
Uranium 238	2.26E+05	
Americium 241	1.36E+05	
Plutonium 239 & 240	1.33E+05	
Tritium (gas)**	6.97E+10	
Strontium 89	1.87E+09	
Strontium 90	9.70E+07	
Cesium 137	1.11E+08	
Radium 226	1.81E+06	
Radium 228	8.36E+06	
Non - Radionuclides	ug/g	ug/g
Arsenic	1.94E+05	
Barium		6.94E+07
Beryllium	1.16E+06	
Cadmium	1.59E+06	
Chromium III		3.96E+05
Chromium VI	2.37E+06	3.96E+05
Manganese		7.91E+06
Mercury		5.97E+06
Hexachlorocyclohexane (alpha)	1.54E+06	
Hexachlorocyclohexane (beta)	5.40E+06	
Heptachlor	2.16E+06	
Heptachlor Epoxide	1.07E+06	
Aldrin	5.72E+05	
Dieldrin	6.07E+06	
DDT	2.86E+07	
Chlordane (alpha, gamma)	7.48E+06	
Toxaphene	8.84E+06	
VOCs & Semi - VOCs	ug/g	ug/g
Chloroform	7.08E+04	
1,1,1-Trichloroethane		1.23E+08
Carbon Tetrachloride	4.41E+04	
Benzene	1.91E+05	
Toluene		2.46E+07
Dichloromethane	2.87E+06	3.68E+07
Xylenes		3.68E+06
MEK		3.68E+07
1,2-Dichloroethane	6.30E+04	
Bromomethane		8.19E+05
Carbon Disulfide		1.23E+05
1,1-Dichloroethene	4.78E+03	
1,1-Dichloroethane		4.09E+07
Vinyl Acetate		2.46E+06
1,3-Dichloropropene	4.41E+04	2.46E+05
1,1,2-Trichloroethane	1.01E+05	
Bromoform	1.47E+06	
Tetrachloroethene	3.18E+06	
Chlorobenzene		2.05E+06
Ethylbenzene		1.23E+07
Styrene	2.87E+06	
Vinyl Chloride	1.98E+05	
1,2-Dichloroethane	6.30E+04	
1,2-Dichloropropane	4.41E+04	
1,1,2,2-Tetrachloroethane	2.87E+04	
2-Chloroethyl Ether	5.21E+03	
1,4-Dichlorobenzene		8.19E+06
1,2-Dichlorobenzene		1.64E+07
Nitrobenzene		2.46E+05
Hexachloroethane	4.09E+05	
1,2,4-Trichlorobenzene		1.23E+06
Hexachlorobutadiene	7.35E+04	
Hexachlorocyclopentadiene		8.19E+03
2,4,6-Trichlorophenol	5.21E+05	
Hexachlorobenzene	3.58E+03	

Vehicle Traffic - Light(10 VKTDwt) - Zone C

DESCRIPTION: The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation > = .254mm.

----- = variables requiring input

Variable	Unit	Parameter
For Respirable Fines <= 10um, K = 0.45		
$BHE(\text{kg/VKT}) = K(1.7)(d/12)(S/48)(W/2.7) \wedge .7(w/4) \wedge .5((365-p)/365)$ (note 1)		
Silt Content	%	50.1
S, Mean Vehicle Speed	km/hr	16
W, Mean Vehicle Weight	Mg	2.7
P, Mean Number of Wheels		4
P, Days with Prec. > = 0.254mm	hr	40
T, Duration of Activity	km	10
D, Total Vehicle Distance Travelled		10
VOC Total (note 2)		0.00
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/h	2.63E-07
Radionuclide Emission Rate (note 4)	pCi/h	2.63E-01
VOC Emission Rate	g/h	0.00E+00

Turners X/Q				
Contaminant Dispersion				
Variable	Unit	Parameter	Remark	
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-07	Receptor @ 4.4 km	
Q2, Emission Rate - Non-Radionuclides	g/sec.	2.63E-01		
Q3, Emission Rate - VOCs	g/sec.	0.00E+00		
P1	m	3.14	270 Class Destability	
Sigma y	m		82 Class Destability	
Sigma z	m		4.7	
Wind speed	m/sec			
Contaminant Concentrations at Fenceline				
Non-Radionuclides	mg/m ³	8.06E-10		
Radionuclides	pCi/m ³	8.06E-07		
VOCs	mg/m ³	0.00E+00		
Initial Concentrations of Contaminants in Soil at Source				
Radionuclides (pCi/g)	1.00E+00			
Non-Rad's (ug/g or ppm)	1.00E+00			
VOCs (ug/g or ppm)	1.00E+00			

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

Note 1: Reference Memorandum from Tom Tsai, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs emissions are assumed to be negligible for this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Vehicle Traffic - Light(10 V KI/Day) - Zone C

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	pCi/m ³	8.06E-07
Intake/Exposure Period	pCi	7.06E-03

EPA L.E.C.R.

Uranium 233 & 234	2E-10
Uranium 235	2E-10
Uranium 238	2E-10
Americium 241	3E-10
Plutonium 239 & 240	3E-10
Tritium (gas)**	6E-16
Strontium 89	2E-14
Strontium 90	4E-13
Cesium 137	3E-13
Radium 226	2E-11
Radium 228	5E-12

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	mg/m ³	8.06E-10
Intake/Exposure Period	mg	7.06E-06
Carcinogen Dose Rate	mg/kg/day	3.95E-12
Non-Carc. Dose Rate	mg/kg/day	5.53E-11

EPA L.E.C.R.

Arsenic	2E-10
Beryllium	3E-11
Cadmium	2E-11
Chromium VI	2E-11
a-Hexachlorocyclohexane	2E-11
B-Hexachlorocyclohexane	7E-12
Heptachlor	2E-11
Heptachlor Epoxide	4E-11
Aldrin	7E-11
Dieldrin	6E-12
DDT	1E-12
Chlordane (alpha, gamma)	5E-12
Toxaphene	4E-12

Hazard Quotient

Barium	6E-08
Chromium III	1E-05
Chromium VI	1E-05
Manganese	5E-07
Mercury	6E-07

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	mg/m ³	0.00E+00
Intake/Exposure Period	mg	0.00E+00
Carcinogen Dose Rate	mg/kg/day	0.00E+00
Non-Carc. Dose Rate	mg/kg/day	0.00E+00

EPA L.E.C.R.

Chloroform	0E+00
Carbon Tetrachloride	0E+00
Benzene	0E+00
Dichloromethane	0E+00
1,2-Dichloroethane	0E+00
1,1-Dichloroethene	0E+00
1,3-Dichloropropene	0E+00
1,1,2-Trichloroethane	0E+00
Bromoform	0E+00
Tetrachloroethene	0E+00
Styrene	0E+00
Vinyl Chloride	0E+00
1,2-Dichloroethane	0E+00
1,2-Dichloropropene	0E+00
1,1,2,2-Tetrachloroethane	0E+00
2-Chloroethyl Ether	0E+00
Hexachloroethane	0E+00
Hexachlorobutadiene	0E+00
2,4,6-Trichlorophenol	0E+00
Hexachlorobenzene	0E+00

Hazard Quotient

1,1,1-Trichloroethane	0E+00
Toluene	0E+00
Dichloromethane	0E+00
Xylenes	0E+00
MEK	0E+00
Bromomethane	0E+00
Carbon Disulfide	0E+00
1,1-Dichloroethane	0E+00
Vinyl Acetate	0E+00
1,3-Dichloropropene	0E+00
Chlorobenzene	0E+00
Ethylbenzene	0E+00
1,4-Dichlorobenzene	0E+00
1,2-Dichlorobenzene	0E+00
Nitrobenzene	0E+00
1,2,4-Trichlorobenzene	0E+00
Hexachlorocyclopentadiene	0E+00

Vehicle Traffic - Light(10 VKT/Day) - Zone C
EPA Threshold Levels

L.E.C.R **HI**
Threshold Conc. **Threshold Conc.**

Radionuclides

pCi/g

Uranium 233 & 234	5.25E+03
Uranium 235	5.67E+03
Uranium 238	5.90E+03
Americium 241	3.54E+03
Plutonium 239 & 240	3.45E+03
Tritium (gas)**	1.82E+09
Strontium 89	4.88E+07
Strontium 90	2.53E+06
Cesium 137	2.89E+06
Radium 226	4.72E+04
Radium 228	2.18E+05

Non - Radionuclides

ug/g

ug/g

Arsenic	5.07E+03	
Barium		1.81E+06
Beryllium	3.02E+04	
Cadmium	4.15E+04	
Chromium III		1.03E+04
Chromium VI	6.18E+04	1.03E+04
Manganese		2.06E+05
Mercury		1.56E+05
Hexachlorocyclohexane (alpha)	4.02E+04	
Hexachlorocyclohexane (beta)	1.41E+05	
Heptachlor	5.63E+04	
Heptachlor Epoxide	2.78E+04	
Aldrin	1.49E+04	
Dieldrin	1.58E+05	
DDT	7.45E+05	
Chlordane (alpha, gamma)	1.95E+05	
Toxaphene	2.30E+05	

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

DESCRIPTION: The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation > = .254mm.

Vehicle Traffic -- Heavy (100 VKT/Day) -- Zone C

For Respirable Fines < = 10um, K = 0.45
 $EHE(kg/VKT) = K(1.7)(w/12)(S/48)(W/2.7)^{-1} \cdot 7(w/4)^{-1} \cdot 5(365-p)/365$ (note 1)

Variable	Unit	Parameter
S, Silt Content	%	0.3
S, Mean Vehicle Speed	km/hr	16
W, Mean Vehicle Weight	Mg	2.7
w, Mean Number of Wheels		4
P, Days with Prec. > = 0.254mm	hr	40
T, Duration of Activity	km	10
D, Total Vehicle Distance Travelled		100
VOC Total (note 2)		0.00

Emissions at Source (note 3)

Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/h	2.63E-06
Radionuclide Emission Rate (note 4)	pCi/h	2.63E+00
VOCs Emission Rate	g/h	0.00E+00

Note 1: Reference Memorandum from Tom Tatinic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984, Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs emissions are assumed to be negligible for this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q	Variable	Unit	Parameter	Remark
Contaminant Dispersion	Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-06	Receptor @
	Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E+00	4.4 km
	Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi			3.14	
Sigma y		m	270	Class Datability
Sigma z		m	82	
Wind speed		m/sec	4.7	
Contaminant Concentrations at Fenceline				
Non-Radionuclides		mg/m^3	8.06E-09	
Radionuclides		pCi/m^3	8.06E-06	
VOCs		mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source				
Radionuclides (pCi/g)			1.00E+00	
Non-Rad's (ug/g or ppm)			1.00E+00	
VOCs (ug/g or ppm)			1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

= variables requiring input

Vehicle Traffic - Heavy(100 VKT/Day) - Zone C

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	8.06E-06
Intake/Exposure Period	pCi	7.06E-02

EPA L.E.C.R.

Uranium 233 & 234	2E-09
Uranium 235	2E-09
Uranium 238	2E-09
Americium 241	3E-09
Plutonium 239 & 240	3E-09
Tritium (gas)**	6E-15
Strontium 89	2E-13
Strontium 90	4E-12
Cesium 137	3E-12
Radium 226	2E-10
Radium 228	5E-11

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	8.06E-09
Intake/Exposure Period	mg	7.06E-05
Carcinogen Dose Rate	mg/kg/day	3.95E-11
Non-Carc. Dose Rate	mg/kg/day	5.53E-10

EPA L.E.C.R.

Arsenic	2E-09
Beryllium	3E-10
Cadmium	2E-10
Chromium VI	2E-10
a-Hexachlorocyclohexane	2E-10
B-Hexachlorocyclohexane	7E-11
Heptachlor	2E-10
Heptachlor Epoxide	4E-10
Aldrin	7E-10
Dieldrin	6E-11
DDT	1E-11
Chlordane (alpha, gamma)	5E-11
Toxaphene	4E-11

Hazard Quotient

Barium	6E-07
Chromium III	1E-04
Chromium VI	1E-04
Manganese	5E-06
Mercury	6E-06

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	0.00E+00
Intake/Exposure Period	mg	0.00E+00
Carcinogen Dose Rate	mg/kg/day	0.00E+00
Non-Carc. Dose Rate	mg/kg/day	0.00E+00

EPA L.E.C.R.

Chloroform	0E+00
Carbon Tetrachloride	0E+00
Benzene	0E+00
Dichloromethane	0E+00
1,2-Dichloroethane	0E+00
1,1-Dichloroethene	0E+00
1,3-Dichloropropene	0E+00
1,1,2-Trichloroethane	0E+00
Bromoform	0E+00
Tetrachloroethene	0E+00
Styrene	0E+00
Vinyl Chloride	0E+00
1,2-Dichloroethane	0E+00
1,2-Dichloropropene	0E+00
1,1,2,2-Tetrachloroethane	0E+00
2-Chloroethyl Ether	0E+00
Hexachloroethane	0E+00
Hexachlorobutadiene	0E+00
2,4,6-Trichlorophenol	0E+00
Hexachlorobenzene	0E+00

Hazard Quotient

1,1,1-Trichloroethane	0E+00
Toluene	0E+00
Dichloromethane	0E+00
Xylenes	0E+00
MEK	0E+00
Bromomethane	0E+00
Carbon Disulfide	0E+00
1,1-Dichloroethane	0E+00
Vinyl Acetate	0E+00
1,3-Dichloropropene	0E+00
Chlorobenzene	0E+00
Ethylbenzene	0E+00
1,4-Dichlorobenzene	0E+00
1,2-Dichlorobenzene	0E+00
Nitrobenzene	0E+00
1,2,4-Trichlorobenzene	0E+00
Hexachlorocyclopentadiene	0E+00

Vehicle Traffic - Heavy(100 VKT/Day) - Zone C
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	5.25E+02	
Uranium 235	5.67E+02	
Uranium 238	5.90E+02	
Americium 241	3.54E+02	
Plutonium 239 & 240	3.45E+02	
Tritium (gas)**	1.82E+08	
Strontium 89	4.88E+06	
Strontium 90	2.53E+05	
Cesium 137	2.89E+05	
Radium 226	4.72E+03	
Radium 228	2.18E+04	
Non-Radionuclides	ug/g	ug/g
Arsenic	5.07E+02	
Barium		1.81E+05
Beryllium	3.02E+03	
Cadmium	4.15E+03	
Chromium III		1.03E+03
Chromium VI	6.18E+03	1.03E+03
Manganese		2.06E+04
Mercury		1.56E+04
Hexachlorocyclohexane (alpha)	4.02E+03	
Hexachlorocyclohexane (beta)	1.41E+04	
Heptachlor	5.63E+03	
Heptachlor Epoxide	2.78E+03	
Aldrin	1.49E+03	
Dieldrin	1.58E+04	
DDT	7.45E+04	
Chlordane (alpha, gamma)	1.95E+04	
Toxaphene	2.30E+04	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

DESCRIPTION:

BATCH DROP CALCULATION - TESTPITS - ZONE C

For Respirable Fines <= 15um, K = 0.48
 $EHE(kg/Mg) = K(0.0009)[(s/5)(U/2.2)(H/1.5)]^{1/2}[(M/2)^{-1/2} + 2(Y/4.6)^{-1/2}]$ (note 1)

Variable	Unit	Parameter
s, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	1
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	0.25
T, Duration of Activity	hr	1.22
D, Depth of Excavation	m	3.95
V, Volume of Excavation	m ³	1.22
DT, Bulk Density of Soil	Mg/m ³	1.50
MT, Total Mass of Soil/Pit	Mg	5.92
VOC Total (note 2)	g	5.9
Assuming one pit constructed per day for five years gives a total number of pits equal to:		1825
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	6.43E-04
Non-Radionuclide (solids) Emission Rate	g/h	1.06E-10
Radionuclide Emission Rate (note 4)	pCi/h	1.32E-05
VOCs Emission Rate	g/h	1.65E-04

Note 1: Reference Memorandum from Tom Tisink, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

= variables requiring input

Turners X/O	Contaminant Dispersion Variable	Unit	Parameter	Remark
	Q1, Emission Rate - Non-Radionuclides	g/sec.	1.06E-10	Receptor @ 4.4 km
	Q2, Emission Rate - Radionuclides	pCi/sec.	1.32E-05	
	Q3, Emission Rate - VOCs	g/sec.	1.65E-04	
	Pi	m	3.14	
	Signaz	m	270	Class Datability
	Sigma z	m	82	Class Datability
	Wind speed	m/sec	4.7	
	Contaminant Concentrations at Fenceline			
	Non-Radionuclides	mg/m ³	3.24E-13	
	Radionuclides	pCi/m ³	4.03E-11	
	VOCs	mg/m ³	5.04E-07	
	Initial Concentrations of Contaminants in Soil at Source			
	Radionuclides (pCi/g)	1.00E+00		
	Non-Rad's (ug/g or ppm)	1.00E+00		
	VOCs (ug/g or ppm)	1.00E+00		

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

BATCH DROP CALCULATION - TEST PITS - ZONE C

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	4.03E-11	
Intake/Exposure Period	pCi	3.53E-07	
EPA L.E.C.R.			
Uranium 233 & 234		1E-14	
Uranium 235		9E-15	
Uranium 238		8E-15	
Americium 241		1E-14	
Plutonium 239 & 240		1E-14	
Tritium (gas)**		3E-20	
Strontium 89		1E-18	
Strontium 90		2E-17	
Cesium 137		2E-17	
Radium 226		1E-15	
Radium 228		2E-16	
Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.24E-13	
Intake/Exposure Period	mg	2.84E-09	
Carcinogen Dose Rate	mg/kg/day	1.59E-15	
Non-Carc. Dose Rate	mg/kg/day	2.22E-14	
EPA L.E.C.R.			
Arsenic		8E-14	
Beryllium		1E-14	
Cadmium		1E-14	
Chromium VI		7E-15	
a-Hexachlorocyclohexane		1E-14	
B-Hexachlorocyclohexane		3E-15	
Heptachlor		7E-15	
Heptachlor Epoxide		1E-14	
Aldrin		3E-14	
Dieldrin		3E-15	
DDT		5E-16	
Chlordane (alpha, gamma)		2E-15	
Toxaphene		2E-15	
Hazard Quotient			
Barium		2E-11	
Chromium III		4E-09	
Chromium VI		4E-09	
Manganese		2E-10	
Mercury		3E-10	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	5.04E-07	
Intake/Exposure Period	mg	4.41E-03	
Carcinogen Dose Rate	mg/kg/day	2.47E-09	
Non-Carc. Dose Rate	mg/kg/day	3.45E-08	
EPA L.E.C.R.			
Chloroform		2E-10	
Carbon Tetrachloride		3E-10	
Benzene		7E-11	
Dichloromethane		5E-12	
1,2-Dichloroethane		2E-10	
1,1-Dichloroethene		3E-09	
1,3-Dichloropropene		3E-10	
1,1,2-Trichloroethane		1E-10	
Bromoform		1E-11	
Tetrachloroethene		4E-12	
Styrene		5E-12	
Vinyl Chloride		7E-11	
1,2-Dichloroethane		2E-10	
1,2-Dichloropropane		3E-10	
1,1,2,2-Tetrachloroethane		5E-10	
2-Chloroethyl Ether		3E-09	
Hexachlorethane		3E-11	
Hexachlorobutadiene		2E-10	
2,4,6-Trichlorophenol		3E-11	
Hexachlorobenzene		4E-09	
Hazard Quotient			
1,1,1-Trichloroethane		1E-08	
Toluene		6E-08	
Dichloromethane		4E-08	
Xylenes		4E-07	
MEK		4E-08	
Bromomethane		2E-06	
Carbon Disulfide		1E-05	
1,1-Dichloroethane		3E-08	
Vinyl Acetate		6E-07	
1,3-Dichloropropene		6E-06	
Chlorobenzene		7E-07	
Ethylbenzene		1E-07	
1,4-Dichlorobenzene		2E-07	
1,2-Dichlorobenzene		9E-08	
Nitrobenzene		6E-06	
1,2,4-Trichlorobenzene		1E-06	
Hexachlorocyclopentadiene		2E-04	

BATCH DROP CALCULATION - TEST PITS - ZONE C

EPA Threshold Levels

L.E.C.R
Threshold Conc. HI
Threshold Conc.

Radionuclides

pCi/g

Uranium 233 & 234	1.05E+08
Uranium 235	1.13E+08
Uranium 238	1.18E+08
Americium 241	7.07E+07
Plutonium 239 & 240	6.90E+07
Tritium (gas)**	3.63E+13
Strontium 89	9.76E+11
Strontium 90	5.05E+10
Cesium 137	5.78E+10
Radium 226	9.43E+08
Radium 228	4.35E+09

Non-Radionuclides

ug/g

ug/g

Arsenic	1.26E+07	
Barium		4.50E+09
Beryllium	7.51E+07	
Cadmium	1.03E+08	
Chromium III		2.57E+07
Chromium VI	1.54E+08	2.57E+07
Manganese		5.13E+08
Mercury		3.87E+08
Hexachlorocyclohexane (alpha)	1.00E+08	
Hexachlorocyclohexane (beta)	3.50E+08	
Heptachlor	1.40E+08	
Heptachlor Epoxide	6.93E+07	
Aldrin	3.71E+07	
Dieldrin	3.94E+08	
DDT	1.85E+09	
Chlordane (alpha, gamma)	4.85E+08	
Toxaphene	5.73E+08	

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform	5.00E+03	8.69E+06
1,1,1-Trichloroethane		
Carbon Tetrachloride	3.12E+03	
Benzene	1.35E+04	
Toluene		1.74E+06
Dichloromethane	2.03E+05	2.61E+06
Xylenes		2.61E+05
MEK		2.61E+06
1,2-Dichloroethane	4.45E+03	
Bromomethane		5.79E+04
Carbon Disulfide		8.69E+03
1,1-Dichloroethene	3.38E+02	
1,1-Dichloroethane		2.90E+06
Vinyl Acetate		1.74E+05
1,3-Dichloropropene	3.12E+03	1.74E+04
1,1,2-Trichloroethane	7.11E+03	
Bromoform	1.04E+05	
Tetrachloroethene	2.25E+05	
Chlorobenzene		1.45E+05
Ethylbenzene		8.69E+05
Styrene	2.03E+05	
Vinyl Chloride	1.40E+04	
1,2-Dichloroethane	4.45E+03	
1,2-Dichloropropane	3.12E+03	
1,1,2,2-Tetrachloroethane	2.03E+03	
2-Chloroethyl Ether	3.68E+02	
1,4-Dichlorobenzene		5.79E+05
1,2-Dichlorobenzene		1.16E+06
Nitrobenzene		1.74E+04
Hexachloroethane	2.90E+04	
1,2,4-Trichlorobenzene		8.69E+04
Hexachlorobutadiene	5.20E+03	
Hexachlorocyclopentadiene		5.79E+02
2,4,6-Trichlorophenol	3.68E+04	
Hexachlorobenzene	2.53E+02	

DESCRIPTION:

TOPSOIL REMOVED BY SCRAPER - ZONE C

For Reptable Fines $\leq 15\mu$
 $EHE(kg/Mg) = 0.019kg/Mg$ of Soil Removed (note 1)

Variable	Unit	Parameter
A, Area Subject to Topsoil Removal	m ²	29500
D, Depth of Topsoil Removal	m	0.3
DT, Bulk Density of Soil	Mg/m ³	1.5
V, Volume of Topsoil to be Removed	m ³	8862
T, Total Period of Removal	hr	317
MT, Total Mass of Topsoil Removed	Mg	13293
VOC Total (note 2)	g	13293
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	1.90E-02
Non-Radionuclide (solids) Emission Rate	g/h	2.21E-07
Radionuclide Emission Rate (note 4)	pCi/h	1.10E-01
VOCs Emission Rate	g/h	1.16E-02

Note 1: Reference Memorandum from Tom Tishnic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

The relationship for predicting fugitive dust emissions during topsoil removal by scraper is on a per mass unit basis of soil removed.

= variables requiring input

Turners X/Q	Contaminant Dispersion	Unit	Parameter	Remark
Variable	-----	-----	-----	-----
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.21E-07	Receptor @	
Q2, Emission Rate - Radionuclides	pCi/sec.	1.10E-01	4.4 km	
Q3, Emission Rate - VOCs	g/sec.	1.16E-02		
P1		3.14		
Sigma y	m	270	Class Destability	
Sigma z	m	82	Class Destability	
Wind speed	m/sec	4.7		
Contaminant Concentrations at Fence/line				
Non-Radionuclides	mg/m ³	6.76E-10		
Radionuclides	pCi/m ³	3.38E-07		
VOCs	mg/m ³	3.56E-05		
Initial Concentrations of Contaminants in Soil at Source				
Radionuclides (pCi/g)	1.00E+00			
Non-Rad's (ug/g or ppm)	1.00E+00			
VOCs (ug/g or ppm)	1.00E+00			

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

TOPSOIL REMOVED BY SCRAPER - ZONE C

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	3.38E-07
Intake/Exposure Period	pCi	2.96E-03

EPA L.E.C.R.

Uranium 233 & 234	8E-11
Uranium 235	7E-11
Uranium 238	7E-11
Americium 241	1E-10
Plutonium 239 & 240	1E-10
Tritium (g _s)**	2E-16
Strontium 89	9E-15
Strontium 90	2E-13
Cesium 137	1E-13
Radium 226	9E-12
Radium 228	2E-12

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	6.76E-10
Intake/Exposure Period	mg	5.92E-06
Carcinogen Dose Rate	mg/kg/day	3.31E-12
Non-Carc. Dose Rate	mg/kg/day	4.64E-11

EPA L.E.C.R.

Arsenic	2E-10
Beryllium	3E-11
Cadmium	2E-11
Chromium VI	1E-11
a-Hexachlorocyclohexane	2E-11
B-Hexachlorocyclohexane	6E-12
Heptachlor	1E-11
Heptachlor Epoxide	3E-11
Aldrin	6E-11
Dieldrin	5E-12
DDT	1E-12
Chlordane (alpha, gamma)	4E-12
Toxaphene	4E-12

Hazard Quotient

Barium	5E-08
Chromium III	8E-06
Chromium VI	8E-06
Manganese	4E-07
Mercury	5E-07

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	3.56E-05
Intake/Exposure Period	mg	3.12E-01
Carcinogen Dose Rate	mg/kg/day	1.74E-07
Non-Carc. Dose Rate	mg/kg/day	2.44E-06

EPA L.E.C.R.

Chloroform	1E-08
Carbon Tetrachloride	2E-08
Benzene	5E-09
Dichloromethane	3E-10
1,2-Dichloroethane	2E-08
1,1-Dichloroethene	2E-07
1,3-Dichloropropene	2E-08
1,1,2-Trichloroethane	1E-08
Bromoform	7E-10
Tetrachloroethene	3E-10
Styrene	3E-10
Vinyl Chloride	5E-09
1,2-Dichloroethane	2E-08
1,2-Dichloropropene	2E-08
1,1,2,2-Tetrachloroethane	3E-08
2-Chloroethyl Ether	2E-07
Hexachloroethane	2E-09
Hexachlorobutadiene	1E-08
2,4,6-Trichlorophenol	2E-09
Hexachlorobenzene	3E-07

Hazard Quotient

1,1,1-Trichloroethane	8E-07
Toluene	4E-06
Dichloromethane	3E-06
Xylenes	3E-05
MEK	3E-06
Bromomethane	1E-04
Carbon Disulfide	8E-04
1,1-Dichloroethane	2E-06
Vinyl Acetate	4E-05
1,3-Dichloropropene	4E-04
Chlorobenzene	5E-05
Ethylbenzene	8E-06
1,4-Dichlorobenzene	1E-05
1,2-Dichlorobenzene	6E-06
Nitrobenzene	4E-04
1,2,4-Trichlorobenzene	8E-05
Hexachlorocyclopentadiene	1E-02

TOPSOIL REMOVED BY SCRAPER - ZONE C
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides		
	pCi/g	
Uranium 233 & 234	1.25E+04	
Uranium 235	1.35E+04	
Uranium 238	1.41E+04	
Americium 241	8.44E+03	
Plutonium 239 & 240	8.23E+03	
Tritium (gas)* *	4.33E+09	
Strontium 89	1.16E+08	
Strontium 90	6.03E+06	
Cesium 137	6.89E+06	
Radium 226	1.13E+05	
Radium 228	5.19E+05	
Non - Radionuclides		
	ug/g	ug/g
Arsenic	6.04E+03	
Barium		2.16E+06
Beryllium	3.59E+04	
Cadmium	4.95E+04	
Chromium III		1.23E+04
Chromium VI	7.36E+04	1.23E+04
Manganese		2.46E+05
Mercury		1.85E+05
Hexachlorocyclohexane (alpha)	4.79E+04	
Hexachlorocyclohexane (beta)	1.68E+05	
Heptachlor	6.71E+04	
Heptachlor Epoxide	3.32E+04	
Aldrin	1.78E+04	
Dieldrin	1.89E+05	
DDT	8.88E+05	
Chlordane (alpha, gamma)	2.32E+05	
Toxaphene	2.74E+05	
VOCs & Semi-VOCs		
	ug/g	ug/g
Chloroform	7.08E+01	
1,1,1-Trichloroethane		1.23E+05
Carbon Tetrachloride	4.41E+01	
Benzene	1.91E+02	
Toluene		2.46E+04
Dichloromethane	2.87E+03	3.69E+04
Xylenes		3.69E+03
MEK		3.69E+04
1,2-Dichloroethane	6.30E+01	
Bromomethane		8.19E+02
Carbon Disulfide		1.23E+02
1,1-Dichloroethene	4.78E+00	
1,1-Dichloroethane		4.10E+04
Vinyl Acetate		2.46E+03
1,3-Dichloropropene	4.41E+01	2.46E+02
1,1,2-Trichloroethane	1.01E+02	
Bromoform	1.47E+03	
Tetrachloroethene	3.19E+03	
Chlorobenzene		2.05E+03
Ethylbenzene		1.23E+04
Styrene	2.87E+03	
Vinyl Chloride	1.98E+02	
1,2-Dichloroethane	6.30E+01	
1,2-Dichloropropane	4.41E+01	
1,1,2,2-Tetrachloroethane	2.87E+01	
2-Chloroethyl Ether	5.21E+00	
1,4-Dichlorobenzene		8.19E+03
1,2-Dichlorobenzene		1.64E+04
Nitrobenzene		2.46E+02
Hexachloroethane	4.10E+02	
1,2,4-Trichlorobenzene		1.23E+03
Hexachlorobutadiene	7.35E+01	
Hexachlorocyclopentadiene		8.19E+00
2,4,6-Trichlorophenol	5.21E+02	
Hexachlorobenzene	3.58E+00	

DESCRIPTION: TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE C

The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

Variable	Unit	Parameter
For Respirable Fines <=15um, K = 0.48		
$EHE(kg/Mg) = K(0.0009)[(d/5)(U/2.2)(H/1.5)][(M/2)^{-2}(Y/4.6)^{-3}]$ (note 1)		
s, Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	1
M, Moisture Content	%	10
Y, Bucket Capacity	m^3	10.70
T, Total Period of Unloading	hr	317
D, Depth of Excavation	m	0.30
A, Area of Topsoil Removed	m^2	295.40
DT, Bulk Density of Soil	Mg/m^3	1.50
MT, Total Mass of Topsoil	Mg	13293
VOC Total (note 2)	g	0.0
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	1.87E-04
Non-Radionuclide (solids) Emission Rate	g/s	2.17E-09
Radionuclide Emission Rate (note 4)	pCi/s	1.09E-03
VOCs Emission Rate	g/s	0.00E+00

Turners X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.17E-09	Receptor @ 4.4 km
Q2, Emission Rate - Radionuclides	pCi/sec.	1.09E-03	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
P1		3.14	
Sigma y	m	270	Class D stability
Sigma z	m	82	Class D stability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m^3	6.64E-12	
Radionuclides	pCi/m^3	3.32E-09	
VOCs	mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		0.00E+00	

Note 1: Reference Memorandum from Tom Tustin, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during the removal by scraper activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE C

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	3.32E-09
Intake/Exposure Period	pCi	2.91E-05
EPA L.E.C.R.		
Uranium 233 & 234		8E-13
Uranium 235		7E-13
Uranium 238		7E-13
Americium 241		1E-12
Plutonium 239 & 240		1E-12
Tritium (gs)**		2E-18
Strontium 89		8E-17
Strontium 90		2E-15
Cesium 137		1E-15
Radium 226		9E-14
Radium 228		2E-14

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	6.64E-12
Intake/Exposure Period	mg	5.82E-08
Carcinogen Dose Rate	mg/kg/day	3.25E-14
Non-Carc. Dose Rate	mg/kg/day	4.56E-13
EPA L.E.C.R.		
Arsenic		2E-12
Beryllium		3E-13
Cadmium		2E-13
Chromium VI		1E-13
a-Hexachlorocyclohexane		2E-13
B-Hexachlorocyclohexane		6E-14
Heptachlor		1E-13
Heptachlor Epoxide		3E-13
Aldrin		6E-13
Dieldrin		5E-14
DDT		1E-14
Chlordane (alpha, gamma)		4E-14
Toxaphene		4E-14
Hazard Quotient		
Barium		5E-10
Chromium III		8E-08
Chromium VI		8E-08
Manganese		4E-09
Mercury		5E-09

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	0.00E+00
Intake/Exposure Period	mg	0.00E+00
Carcinogen Dose Rate	mg/kg/day	0.00E+00
Non-Carc. Dose Rate	mg/kg/day	0.00E+00
EPA L.E.C.R.		
Chloroform		0E+00
Carbon Tetrachloride		0E+00
Benzene		0E+00
Dichloromethane		0E+00
1,2-Dichloroethane		0E+00
1,1-Dichloroethene		0E+00
1,3-Dichloropropene		0E+00
1,1,2-Trichloroethane		0E+00
Bromoform		0E+00
Tetrachloroethene		0E+00
Styrene		0E+00
Vinyl Chloride		0E+00
1,2-Dichloropropane		0E+00
1,1,2,2-Tetrachloroethane		0E+00
2-Chloroethyl Ether		0E+00
Hexachloroethane		0E+00
Hexachlorobutadiene		0E+00
2,4,6-Trichlorophenol		0E+00
Hexachlorobenzene		0E+00
Hazard Quotient		
1,1,1-Trichloroethane		0E+00
Toluene		0E+00
Dichloromethane		0E+00
Xylenes		0E+00
MEK		0E+00
Bromomethane		0E+00
Carbon Disulfide		0E+00
1,1-Dichloroethane		0E+00
Vinyl Acetate		0E+00
1,3-Dichloropropene		0E+00
Chlorobenzene		0E+00
Ethylbenzene		0E+00
1,4-Dichlorobenzene		0E+00
1,2-Dichlorobenzene		0E+00
Nitrobenzene		0E+00
1,2,4-Trichlorobenzene		0E+00
Hexachlorocyclopentadiene		0E+00

TOPSOIL UNLOADING BY SCRAPER (BATCH DROP) - ZONE C
EPA Threshold Levels
L.E.C.R. HI
Threshold Conc. Threshold Conc.
Radionuclides
pCi/g

Uranium 233 & 234	1.27E+06
Uranium 235	1.37E+06
Uranium 238	1.43E+06
Americium 241	8.59E+05
Plutonium 239 & 240	8.38E+05
Tritium (gas)**	4.41E+11
Strontium 89	1.19E+10
Strontium 90	6.14E+08
Cesium 137	7.01E+08
Radium 226	1.15E+07
Radium 228	5.29E+07

Non-Radionuclides
ug/g
ug/g

Arsenic	6.15E+05	
Barium		2.20E+08
Beryllium	3.66E+06	
Cadmium	5.04E+06	
Chromium III		1.25E+06
Chromium VI	7.50E+06	1.25E+06
Manganese		2.50E+07
Mercury		1.89E+07
Hexachlorocyclohexane (alpha)	4.88E+06	
Hexachlorocyclohexane (beta)	1.71E+07	
Heptachlor	6.83E+06	
Heptachlor Epoxide	3.38E+06	
Aldrin	1.81E+06	
Dieldrin	1.92E+07	
DDT	9.04E+07	
Chlordane (alpha, gamma)	2.36E+07	
Toxaphene	2.79E+07	

VOCs & Semi-VOCs
ug/g
ug/g

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

= variables requiring input

The relationship for predicting fugitive dust emissions during topsoil transportation by scraper is based on the silt content of the soil and the mean scraper weight.

DESCRIPTION:

TOPSOIL TRANSPORTATION BY SCRAPER - ZONE C

For Reusable Fines <= 15um
EHE(kg/VKT)=2.2E-6*(s)^1.4*(W)^2.5 (note 1)

Variable	Unit	Parameter
A, Area Subject to Topsoil Removal	m^2	29540
D, Depth of Topsoil Removal	m	0.3
DT, Bulk Density of Soil	Mg/m^3	1.5
V, Volume of Topsoil to be Removed (Transported)	m^3	8862
T, Total Period of Transporting	hr	317
Total Number of Round Trips (Assumes Scraper Cap.=10.7m^3)		952
s, Silt Content	%	80
W, Mean Scraper Weight	Mg	37.5
RT, Round Trip Distance	km	1.6
MT, Total Mass of Topsoil Transported	Mg	13293
VOC Total	g	0
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/VKT	8.73E+00
Non-Radionuclide (solids) Emission Rate	g/s	1.16E-05
Radionuclide Emission Rate (note 4)	pCi/s	2.34E+01
VOC Emission Rate	g/s	0.00E+00

Note 1: Reference Memorandum from Tom Tatinic, Public Health Engineer, on Fugitive Particulate Emissions, July 2,

1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs emissions are assumed to be negligible during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q	Unit	Parameter	Remark
Contaminant Dispersion			
Q1, Emission Rate - Non-Radionuclides	g/sec.	1.16E-05	Receptor @
Q2, Emission Rate - Radionuclides	pCi/sec.	2.34E+01	4.4 km
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi		3.14	
Sigma y	m	270	Class Dataability
Sigma z	m	82	Class Dataability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Penetration			
Non-Radionuclides	mg/m^3	3.56E-08	
Radionuclides	pCi/m^3	7.16E-05	
VOCs	mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		0.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

TOPSOIL TRANSPORTATION BY SCRAPER - ZONE C

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	7.16E-05	
Intake/Exposure Period	pCi	6.27E-01	
EPA I.E.C.R.			
Uranium 233 & 234		2E-08	
Uranium 235		2E-08	
Uranium 238		2E-08	
Americium 241		3E-08	
Plutonium 239 & 240		3E-08	
Tritium (g _s)**		5E-14	
Strontium 89		2E-12	
Strontium 90		4E-11	
Cesium 137		3E-11	
Radium 226		2E-09	
Radium 228		4E-10	
Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.56E-08	
Intake/Exposure Period	mg	3.12E-04	
Carcinogen Dose Rate	mg/kg/day	1.75E-10	
Non-Carc. Dose Rate	mg/kg/day	2.44E-09	
EPA I.E.C.R.			
Arsenic		9E-09	
Beryllium		1E-09	
Cadmium		1E-09	
Chromium VI		7E-10	
a-Hexachlorocyclohexane		1E-09	
B-Hexachlorocyclohexane		3E-10	
Heptachlor		8E-10	
Heptachlor Epoxide		2E-09	
Aldrin		3E-09	
Dieldrin		3E-10	
DDT		6E-11	
Chlordane (alpha, gamma)		2E-10	
Toxaphene		2E-10	
Hazard Quotient			
Barium		2E-06	
Chromium III		4E-04	
Chromium VI		4E-04	
Manganese		2E-05	
Mercury		3E-05	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	0.00E+00	
Intake/Exposure Period	mg	0.00E+00	
Carcinogen Dose Rate	mg/kg/day	0.00E+00	
Non-Carc. Dose Rate	mg/kg/day	0.00E+00	
EPA I.E.C.R.			
Chloroform		0E+00	
Carbon Tetrachloride		0E+00	
Benzene		0E+00	
Dichloromethane		0E+00	
1,2-Dichloroethane		0E+00	
1,1-Dichloroethene		0E+00	
1,3-Dichloropropene		0E+00	
1,1,2-Trichloroethane		0E+00	
Bromoform		0E+00	
Tetrachloroethene		0E+00	
Styrene		0E+00	
Vinyl Chloride		0E+00	
1,2-Dichloroethane		0E+00	
1,2-Dichloropropene		0E+00	
1,1,2,2-Tetrachloroethane		0E+00	
2-Chloroethyl Ether		0E+00	
Hexachloroethane		0E+00	
Hexachlorobutadiene		0E+00	
2,4,6-Trichlorophenol		0E+00	
Hexachlorobenzene		0E+00	
Hazard Quotient			
1,1,1-Trichloroethane		0E+00	
Toluene		0E+00	
Dichloromethane		0E+00	
Xylenes		0E+00	
MEK		0E+00	
Bromomethane		0E+00	
Carbon Disulfide		0E+00	
1,1-Dichloroethane		0E+00	
Vinyl Acetate		0E+00	
1,3-Dichloropropene		0E+00	
Chlorobenzene		0E+00	
Ethylbenzene		0E+00	
1,4-Dichlorobenzene		0E+00	
1,2-Dichlorobenzene		0E+00	
Nitrobenzene		0E+00	
1,2,4-Trichlorobenzene		0E+00	
Hexachlorocyclopentadiene		0E+00	

TOPSOIL TRANSPORTATION BY SCRAPER - ZONE C

EPA Threshold Levels

L.E.C.R

Threshold Conc.

HI

Threshold Conc.

Radionuclides

pCi/g

Uranium 233 & 234	5.90E+01
Uranium 235	6.38E+01
Uranium 238	6.64E+01
Americium 241	3.99E+01
Plutonium 239 & 240	3.89E+01
Tritium (gas)**	2.04E+07
Strontium 89	5.50E+05
Strontium 90	2.85E+04
Cesium 137	3.25E+04
Radium 226	5.31E+02
Radium 228	2.45E+03

Non-Radionuclides

ug/g

ug/g

Arsenic	1.15E+02	
Barium		4.09E+04
Beryllium	6.82E+02	
Cadmium	9.39E+02	
Chromium III		2.33E+02
Chromium VI	1.40E+03	2.33E+02
Manganese		4.66E+03
Mercury		3.52E+03
Hexachlorocyclohexane (alpha)	9.09E+02	
Hexachlorocyclohexane (beta)	3.18E+03	
Heptachlor	1.27E+03	
Heptachlor Epoxide	6.30E+02	
Aldrin	3.37E+02	
Dieldrin	3.58E+03	
DDT	1.68E+04	
Chlordane (alpha, gamma)	4.41E+03	
Toxaphene	5.21E+03	

VOCs & Semi-VOCs

ug/g

ug/g

Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

DESCRIPTION:

The equation for batch drop operations predicts emission factors based on particle size, silt content, wind speed, drop height, moisture content, and dumping device capacity.

----- variables requiring input

MAJOR EXCAVATION BY FRONT-SHOVEL EXCAVATOR (BATCH DROP) - ZONE C

For Reptable Fines <=15um, K = 0.48
 $EHE(kg/Mg) = K(0.0099)[(e/5)(U/2.2)(H/1.5)]((M/2) \wedge 2(Y/4.6) \wedge .33)$ (note 1)

Variable	Unit	Parameter
% Silt Content	%	50
U, Mean Wind Speed	m/s	4.7
H, Drop Height	m	2
M, Moisture Content	%	10
Y, Bucket Capacity	m ³	3.30
T, Total Period of Excavation	hr	900
V, Total Volume of Excavation	m ³	116400
DT, Bulk Density of Soil	Mg/m ³	1.5
MT, Total Mass of Soil	Mg	174600
VOC Total (note 2)	g	174600
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/Mg	5.40E-04
Non-Radionuclide (solids) Emission Rate	g/s	2.91E-08
Radionuclide Emission Rate (note 4)	pCi/s	0.00E+00
VOCs Emission Rate	g/s	5.39E-02

Turners X/Q Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.91E-08	Receptor @ 4.4 km
Q2, Emission Rate - Radionuclides	pCi/sec.	0.00E+00	
Q3, Emission Rate - VOCs	g/sec.	5.39E-02	
P1		3.14	
Sigma y	m	270	Class Datability
Sigma z	m	83	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fence/line			
Non-Radionuclides	mg/m ³	8.90E-11	
Radionuclides	pCi/m ³	0.00E+00	
VOCs	mg/m ³	1.65E-04	
Initial Concentrations of Contaminants in Soils at Source			
Radionuclides (pCi/g)		0.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Note 1: Reference Memorandum from Tom Tislinic, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted from the soil during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

MAJOR EXCAVATION BY FRONT SHOVEL EXCAVATOR (BATCH DROP) - ZONE C

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	0.00E+00
Intake/Exposure Period	pCi	0.00E+00
EPA L.E.C.R.		
Uranium 233 & 234		0E+00
Uranium 235		0E+00
Uranium 238		0E+00
Americium 241		0E+00
Plutonium 239 & 240		0E+00
Tritium (gas)**		0E+00
Strontium 89		0E+00
Strontium 90		0E+00
Cesium 137		0E+00
Radium 226		0E+00
Radium 228		0E+00

Dose/Risk Estimates - Non-Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	8.90E-11
Intake/Exposure Period	mg	7.80E-07
Carcinogen Dose Rate	mg/kg/day	4.36E-13
Non-Carc. Dose Rate	mg/kg/day	6.10E-12
EPA L.E.C.R.		
Arsenic		2E-11
Beryllium		4E-12
Cadmium		3E-12
Chromium VI		2E-12
a-Hexachlorocyclohexane		3E-12
B-Hexachlorocyclohexane		8E-13
Heptachlor		2E-12
Heptachlor Epoxide		4E-12
Aldrin		7E-12
Dieldrin		7E-13
DDT		1E-13
Chlordane (alpha, gamma)		6E-13
Toxaphene		5E-13
Hazard Quotient		
Barium		6E-09
Chromium III		1E-06
Chromium VI		1E-06
Manganese		5E-08
Mercury		7E-08

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	1.65E-04
Intake/Exposure Period	mg	1.44E+00
Carcinogen Dose Rate	mg/kg/day	8.08E-07
Non-Carc. Dose Rate	mg/kg/day	1.13E-05
EPA L.E.C.R.		
Chloroform		7E-08
Carbon Tetrachloride		1E-07
Benzene		2E-08
Dichloromethane		2E-09
1,2-Dichloroethane		7E-08
1,1-Dichloroethene		1E-06
1,3-Dichloropropene		1E-07
1,1,2-Trichloroethane		5E-08
Bromoform		3E-09
Tetrachloroethene		1E-09
Styrene		2E-09
Vinyl Chloride		2E-08
1,2-Dichloroethane		7E-08
1,2-Dichloropropane		1E-07
1,1,2,2-Tetrachloroethane		2E-07
2-Chloroethyl Ether		9E-07
Hexachlorethane		1E-08
Hexachlorobutadiene		6E-08
2,4,6-Trichlorophenol		9E-09
Hexachlorobenzene		1E-06
Hazard Quotient		
1,1,1-Trichloroethane		4E-06
Toluene		2E-05
Dichloromethane		1E-05
Xylenes		1E-04
MEK		1E-05
Bromomethane		6E-04
Carbon Disulfide		4E-03
1,1-Dichloroethane		1E-05
Vinyl Acetate		2E-04
1,3-Dichloropropene		2E-03
Chlorobenzene		2E-04
Ethylbenzene		4E-05
1,4-Dichlorobenzene		6E-05
1,2-Dichlorobenzene		3E-05
Nitrobenzene		2E-03
1,2,4-Trichlorobenzene		4E-04
Hexachlorocyclopentadiene		6E-02

MAJOR EXCAVATION BY FRONT SHOVEL EXCAVATOR (BATCH DROP) - ZONE C

BPA Threshold Levels

L.E.C.R
Threshold Conc. HI
Threshold Conc.

Radionuclides	pCi/g	
Uranium 233 & 234	N/A	
Uranium 235	N/A	
Uranium 238	N/A	
Americium 241	N/A	
Plutonium 239 & 240	N/A	
Tritium (gas)**	N/A	
Strontium 89	N/A	
Strontium 90	N/A	
Cesium 137	N/A	
Radium 226	N/A	
Radium 228	N/A	
Non-Radionuclides	ug/g	ug/g
Arsenic	4.59E+04	
Barium		1.64E+07
Beryllium	2.73E+05	
Cadmium	3.76E+05	
Chromium III		9.34E+04
Chromium VI	5.59E+05	9.34E+04
Manganese		1.87E+06
Mercury		1.41E+06
Hexachlorocyclohexane (alpha)	3.64E+05	
Hexachlorocyclohexane (beta)	1.27E+06	
Heptachlor	5.10E+05	
Heptachlor Epoxide	2.52E+05	
Aldrin	1.35E+05	
Dieldrin	1.43E+06	
DDT	6.75E+06	
Chlordane (alpha, gamma)	1.76E+06	
Toxaphene	2.08E+06	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	1.53E+01	
1,1,1-Trichloroethane		2.65E+04
Carbon Tetrachloride	9.52E+00	
Benzene	4.13E+01	
Toluene		5.31E+03
Dichloromethane	6.19E+02	7.96E+03
Xylenes		7.96E+02
MEK		7.96E+03
1,2-Dichloroethane	1.36E+01	
Bromomethane		1.77E+02
Carbon Disulfide		2.65E+01
1,1-Dichloroethene	1.03E+00	
1,1-Dichloroethane		8.84E+03
Vinyl Acetate		5.31E+02
1,3-Dichloropropene	9.52E+00	5.31E+01
1,1,2-Trichloroethane	2.17E+01	
Bromoform	3.17E+02	
Tetrachloroethene	6.88E+02	
Chlorobenzene		4.42E+02
Ethylbenzene		2.65E+03
Styrene	6.19E+02	
Vinyl Chloride	4.27E+01	
1,2-Dichloroethane	1.36E+01	
1,2-Dichloropropane	9.52E+00	
1,1,2,2-Tetrachloroethane	6.19E+00	
2-Chloroethyl Ether	1.13E+00	
1,4-Dichlorobenzene		1.77E+03
1,2-Dichlorobenzene		3.54E+03
Nitrobenzene		5.31E+01
Hexachloroethane	8.84E+01	
1,2,4-Trichlorobenzene		2.65E+02
Hexachlorobutadiene	1.59E+01	
Hexachlorocyclopentadiene		1.77E+00
2,4,6-Trichlorophenol	1.13E+02	
Hexachlorobenzene	7.74E-01	

ATTACHMENT A.3.6
OPERABLE UNIT 3 CALCULATIONS

Turners X/Q

Contaminant Dispersion

Variable

Unit

Parameter

Remark

Q1, Emission Rate - Non-Radionuclides

Q2, Emission Rate - Radionuclides

Q3, Emission Rate - VOCs

Pi

Sigma y

Sigma z

Wind speed

Contaminant Concentrations at Fenceline

Non-Radionuclides

mg/m³

mg/m³

mg/m³

mg/m³

mg/m³

mg/m³

mg/m³

mg/m³

mg/m³

Initial Concentrations of Contaminants in Soil at Source

Radionuclides (pCi/g)

Non-Rad's (ug/g or ppm)

VOCs (ug/g or ppm)

1.00E+00

1.00E+00

1.00E+00

1.00E+00

Target Threshold Risk

Target Threshold Hazard Index

1.00E-06

0.1

1.00E-06

0.1

1.00E-06

0.1

HOLE DRILLING - Q113

For Respirable Fines <=15um
EHE(ug/hole) = 0.25 (note 1)

Variable
D, Depth of Hole
DI, Diameter of Hole
DT, Bulk Density of Soil
T, Total Period of Hole Drilling

MT, Total Mass of Soil Removed
VOC Total (note 2)

Emissions at Source: (note 3)

Particulate Emissions from Source
Non-Radionuclide (solids) Emission Rate
Radionuclide Emission Rate (note 4)
VOCs Emission Rate

kg/hole
g/h
pCi/a
g/h

2.50E-01
6.94E-09
6.94E-03
1.18E-05

Note 1: Reference Memorandum from Tom Tietlin, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs are assumed to be completely volatilized and emitted during this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

The equation for hole drilling predicts emissions on a per hole basis.

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HOLE DRILLING - OU3

Dose/Risk Estimates - Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	pCi/m ³	3.29E-07	
Intake/Exposure Period		2.88E-03	
EPA L.E.C.R.			
Uranium 233 & 234		8E-11	
Uranium 235		7E-11	
Uranium 238		7E-11	
Americium 241		1E-10	
Plutonium 239 & 240		1E-10	
Tritium (gas)**		2E-16	
Strontium 89		8E-15	
Strontium 90		2E-13	
Cesium 137		1E-13	
Radium 226		9E-12	
Radium 228		2E-12	
Dose/Risk Estimates - Non-Radionuclides			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	3.29E-10	
Intake/Exposure Period		2.88E-06	
Carcinogen Dose Rate	mg/kg/day	1.61E-12	
Non-Carc. Dose Rate	mg/kg/day	2.26E-11	
EPA L.E.C.R.			
Arsenic		8E-11	
Beryllium		1E-11	
Cadmium		1E-11	
Chromium VI		7E-12	
a-Hexachlorocyclohexane		1E-11	
B-Hexachlorocyclohexane		3E-12	
Heptachlor		7E-12	
Heptachlor Epoxide		1E-11	
Aldrin		3E-11	
Dieldrin		3E-12	
DDT		5E-13	
Chlordane (alpha, gamma)		2E-12	
Toxaphene		2E-12	
Hazard Quotient			
Barium		2E-08	
Chromium III		4E-06	
Chromium VI		4E-06	
Manganese		2E-07	
Mercury		3E-07	
Dose/Risk Estimates - VOCs			
Variable	Unit	Parameter	
Intake Rate	m ³ /hr	1.2	
Intake Duration	hr/day	10	
Exposure Period	Days	1825	
Fract. Leeward Wind Factor		0.4	
Intake Concentration	mg/m ³	5.58E-07	
Intake/Exposure Period		4.89E-03	
Carcinogen Dose Rate	mg/kg/day	2.73E-09	
Non-Carc. Dose Rate	mg/kg/day	3.83E-08	
EPA L.E.C.R.			
Chloroform		2E-10	
Carbon Tetrachloride		4E-10	
Benzene		8E-11	
Dichloromethane		5E-12	
1,2-Dichloroethane		2E-10	
1,1-Dichloroethene		3E-09	
1,3-Dichloropropene		4E-10	
1,1,2-Trichloroethane		2E-10	
Bromoform		1E-11	
Tetrachloroethene		5E-12	
Styrene		5E-12	
Vinyl Chloride		8E-11	
1,2-Dichloropropane		2E-10	
1,2-Dichloroethane		4E-10	
1,1,2,2-Tetrachloroethane		5E-10	
2-Chloroethyl Ether		3E-09	
Hexachlorethane		4E-11	
Hexachlorobutadiene		2E-10	
2,4,6-Trichlorophenol		3E-11	
Hexachlorobenzene		4E-09	
Hazard Quotient			
1,1,1-Trichloroethane		1E-08	
Toluene		6E-08	
Dichloromethane		4E-08	
Xylenes		4E-07	
MEK		4E-08	
Bromomethane		2E-06	
Carbon Disulfide		1E-05	
1,1-Dichloroethane		4E-08	
Vinyl Acetate		6E-07	
1,3-Dichloropropene		6E-06	
Chlorobenzene		8E-07	
Ethylbenzene		1E-07	
1,4-Dichlorobenzene		2E-07	
1,2-Dichlorobenzene		1E-07	
Nitrobenzene		6E-06	
1,2,4-Trichlorobenzene		1E-06	
Hexachlorocyclopentadiene		2E-04	

HOLE DRILLING - OU3**EPA Threshold Levels**

L.E.C.R **HI**
Threshold Conc. **Threshold Conc.**

Radionuclides**pCi/g**

Uranium 233 & 234	1.28E+04
Uranium 235	1.39E+04
Uranium 238	1.45E+04
Americium 241	8.67E+03
Plutonium 239 & 240	8.46E+03
Tritium (gas)**	4.45E+09
Strontium 89	1.20E+08
Strontium 90	6.19E+06
Cesium 137	7.08E+06
Radium 226	1.16E+05
Radium 228	5.34E+05

Non-Radionuclides**ug/g****ug/g**

Arsenic	1.24E+04	
Barium		4.43E+06
Beryllium	7.39E+04	
Cadmium	1.02E+05	
Chromium III		2.53E+04
Chromium VI	1.51E+05	2.53E+04
Manganese		5.05E+05
Mercury		3.81E+05
Hexachlorocyclohexane (alpha)	9.85E+04	
Hexachlorocyclohexane (beta)	3.45E+05	
Heptachlor	1.38E+05	
Heptachlor Epoxide	6.82E+04	
Aldrin	3.65E+04	
Dieldrin	3.88E+05	
DDT	1.82E+06	
Chlordane (alpha, gamma)	4.77E+05	
Toxaphene	5.64E+05	

VOCs & Semi-VOCs**ug/g****ug/g**

Chloroform	4.52E+03	
1,1,1-Trichloroethane		7.84E+06
Carbon Tetrachloride	2.81E+03	
Benzene	1.22E+04	
Toluene		1.57E+06
Dichloromethane	1.83E+05	2.35E+06
Xylenes		2.35E+05
MEK		2.35E+06
1,2-Dichloroethane	4.02E+03	
Bromomethane		5.23E+04
Carbon Disulfide		7.84E+03
1,1-Dichloroethene	3.05E+02	
1,1-Dichloroethane		2.61E+06
Vinyl Acetate		1.57E+05
1,3-Dichloropropene	2.81E+03	1.57E+04
1,1,2-Trichloroethane	6.42E+03	
Bromoform	9.38E+04	
Tetrachloroethene	2.03E+05	
Chlorobenzene		1.31E+05
Ethylbenzene		7.84E+05
Styrene	1.83E+05	
Vinyl Chloride	1.26E+04	
1,2-Dichloroethane	4.02E+03	
1,2-Dichloropropane	2.81E+03	
1,1,2,2-Tetrachloroethane	1.83E+03	
2-Chloroethyl Ether	3.33E+02	
1,4-Dichlorobenzene		5.23E+05
1,2-Dichlorobenzene		1.05E+06
Nitrobenzene		1.57E+04
Hexachloroethane	2.61E+04	
1,2,4-Trichlorobenzene		7.84E+04
Hexachlorobutadiene	4.69E+03	
Hexachlorocyclopentadiene		5.23E+02
2,4,6-Trichlorophenol	3.33E+04	
Hexachlorobenzene	2.29E+02	

DESCRIPTION: The equation for vehicle traffic predictions emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation > = .254mm.

----- = variables requiring input

Vehicle Traffic -- Light(10 V KT/Dav) -- Q13

For Respirable Fines < = 10um, K = 0.45

$$EHE(kg/V KT) = K(1.7)(w/12)(S/48)(W/2.7)^{-.5}(365-p)/365 \text{ (note 1)}$$

Variable	Unit	Parameter
S, Silt Content	%	-----
S, Mean Vehicle Speed	km/hr	50.1
W, Mean Vehicle Weight	Mg	16
w, Mean Number of Wheels		2.7
P, Days with Prec. > = 0.254mm	hr	4
T, Duration of Activity	km	40
D, Total Vehicle Distance Travelled		10
VOC Total (note 2)		0.00

Emissions at Source: (note 3)

Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/h	2.63E-07
Radionuclide Emission Rate (note 4)	pCi/s	2.63E-01
VOCs Emission Rate	g/h	0.00E+00

Note 1: Reference Memorandum from Tom Tustin, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.
 Note 2: VOCs emissions are assumed to be negligible for this activity.
 Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.
 Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q	Unit	Parameter	Remark
Contaminant Dispersion			
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-07	Receptor @
Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E-01	0.8 km
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
P1		3.14	
Sigma y	m	55	Class Datability
Sigma z	m	26	Class Datability
Wind speed	m/sec	4.7	
Contaminant Concentrations at Fence/line			
Non-Radionuclides	mg/m^3	1.25E-08	
Radionuclides	pCi/m^3	1.25E-05	
VOCs	mg/m^3	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rad's (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

Vehicle Traffic - Light(10 VKT/Day) - OU3

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	pCi/m ³	1.25E-05
Intake/Exposure Period	pCi	1.09E-01

EPA L.E.C.R.

Uranium 233 & 234	3E-09
Uranium 235	3E-09
Uranium 238	3E-09
Americium 241	4E-09
Plutonium 239 & 240	4E-09
Tritium (gas)**	9E-15
Strontium 89	3E-13
Strontium 90	6E-12
Cesium 137	5E-12
Radium 226	3E-10
Radium 228	7E-11

Dose/Risk Estimates - Non - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	mg/m ³	1.25E-08
Intake/Exposure Period	mg	1.09E-04
Carcinogen Dose Rate	mg/kg/day	6.11E-11
Non-Carc. Dose Rate	mg/kg/day	8.56E-10

EPA L.E.C.R.

Arsenic	3E-09
Beryllium	5E-10
Cadmium	4E-10
Chromium VI	3E-10
a - Hexachlorocyclohexane	4E-10
B - Hexachlorocyclohexane	1E-10
Heptachlor	3E-10
Heptachlor Epoxide	6E-10
Aldrin	1E-09
Dieldrin	1E-10
DDT	2E-11
Chlordane (alpha, gamma)	8E-11
Toxaphene	7E-11

Hazard Quotient

Barium	9E-07
Chromium III	2E-04
Chromium VI	2E-04
Manganese	8E-06
Mercury	1E-05

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4

Intake Concentration	mg/m ³	0.00E+00
Intake/Exposure Period	mg	0.00E+00
Carcinogen Dose Rate	mg/kg/day	0.00E+00
Non-Carc. Dose Rate	mg/kg/day	0.00E+00

EPA L.E.C.R.

Chloroform	0E+00
Carbon Tetrachloride	0E+00
Benzene	0E+00
Dichloromethane	0E+00
1,2-Dichloroethane	0E+00
1,1-Dichloroethene	0E+00
1,3-Dichloropropene	0E+00
1,1,2-Trichloroethane	0E+00
Bromoform	0E+00
Tetrachloroethene	0E+00
Styrene	0E+00
Vinyl Chloride	0E+00
1,2-Dichloroethane	0E+00
1,2-Dichloropropene	0E+00
1,1,2,2-Tetrachloroethane	0E+00
2-Chloroethyl Ether	0E+00
Hexachlorethane	0E+00
Hexachlorobutadiene	0E+00
2,4,6-Trichlorophenol	0E+00
Hexachlorobenzene	0E+00

Hazard Quotient

1,1,1-Trichloroethane	0E+00
Toluene	0E+00
Dichloromethane	0E+00
Xylenes	0E+00
MEK	0E+00
Bromomethane	0E+00
Carbon Disulfide	0E+00
1,1-Dichloroethane	0E+00
Vinyl Acetate	0E+00
1,3-Dichloropropene	0E+00
Chlorobenzene	0E+00
Ethylbenzene	0E+00
1,4-Dichlorobenzene	0E+00
1,2-Dichlorobenzene	0E+00
Nitrobenzene	0E+00
1,2,4-Trichlorobenzene	0E+00
Hexachlorocyclopentadiene	0E+00

Vehicle Traffic - Light(10 VKT/Day) - OU3
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/g	
Uranium 233 & 234	3.39E+02	
Uranium 235	3.66E+02	
Uranium 238	3.81E+02	
Americium 241	2.29E+02	
Plutonium 239 & 240	2.23E+02	
Tritium (gas)**	1.17E+08	
Strontium 89	3.15E+06	
Strontium 90	1.63E+05	
Cesium 137	1.87E+05	
Radium 226	3.05E+03	
Radium 228	1.41E+04	
Non-Radionuclides	ug/g	ug/g
Arsenic	3.27E+02	
Barium		1.17E+05
Beryllium	1.95E+03	
Cadmium	2.68E+03	
Chromium III		6.66E+02
Chromium VI	3.99E+03	6.66E+02
Manganese		1.33E+04
Mercury		1.01E+04
Hexachlorocyclohexane (alpha)	2.60E+03	
Hexachlorocyclohexane (beta)	9.09E+03	
Heptachlor	3.64E+03	
Heptachlor Epoxide	1.80E+03	
Aldrin	9.63E+02	
Dieldrin	1.02E+04	
DDT	4.81E+04	
Chlordane (alpha, gamma)	1.26E+04	
Toxaphene	1.49E+04	
VOCs & Semi-VOCs	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

DESCRIPTION: The equation for vehicle traffic predicts emissions based on silt content, mean vehicle speed, weight and number of wheels, and the number of days with precipitation $\geq .254\text{mm}$.

Vehicle Traffic - Heavy (100 VKT/day) - 0113

For Resuspendable Fines $\leq 10\mu\text{m}$, $K = 0.45$

$$EHB(\text{kg/VKT}) = K(1.7)(s/12)(S/48)(W/2.7) \wedge .7(w/4) \wedge .5((365-p)/365)$$
 (note 1)

Variable	Unit	Parameter
s, Silt Content	%	50.1
S, Mean Vehicle Speed	km/hr	16
w, Mean Vehicle Weight	Mg	2.7
W, Mean Number of Wheels		4
P, Days with Prec. $\geq 0.254\text{mm}$	yr	40
T, Duration of Activity	km	10
D, Total Vehicle Distance Travelled		100
VOC Total (note 2)		0.00
Emissions at Source: (note 3)		
Particulate Emissions from Source	kg/km	9.48E-01
Non-Radionuclide (solids) Emission Rate	g/s	2.63E-06
Radionuclide Emission Rate (note 4)	pCi/s	2.63E+00
VOCs Emission Rate	g/s	0.00E+00

Note 1: Reference Memorandum from Tom Tishnik, Public Health Engineer, on Fugitive Particulate Emissions, July 2, 1984. Through Colorado Department of Health, Air Pollution Control Division.

Note 2: VOCs emissions are assumed to be negligible for this activity.

Note 3: Contaminant emission rates are based on the assumed initial contaminant concentrations in the soil.

Note 4: Radionuclides are assumed to be distributed only and homogeneously in the top 6 inch layer of soil.

Turners X/Q Contaminant Dispersion Variable	Unit	Parameter	Remark
Q1, Emission Rate - Non-Radionuclides	g/sec.	2.63E-06	Receptor @ 0.8 km
Q2, Emission Rate - Radionuclides	pCi/sec.	2.63E+00	
Q3, Emission Rate - VOCs	g/sec.	0.00E+00	
Pi		3.14	
Sigma y	m	55	Class D stability
Sigma z	m	26	Class D stability
Wind speed	m/sec	4	
Contaminant Concentrations at Fenceline			
Non-Radionuclides	mg/m ³	1.47E-07	
Radionuclides	pCi/m ³	1.47E-04	
VOCs	mg/m ³	0.00E+00	
Initial Concentrations of Contaminants in Soil at Source			
Radionuclides (pCi/g)		1.00E+00	
Non-Rads (ug/g or ppm)		1.00E+00	
VOCs (ug/g or ppm)		1.00E+00	

Target Threshold Risk	1.00E-06
Target Threshold Hazard Index	0.1

--- variables requiring input

Vehicle Traffic - Heavy(100 VKT/Day) - OU3

Dose/Risk Estimates - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	pCi/m ³	1.47E-04
Intake/Exposure Period	pCi	1.28E+00

EPA L.E.C.R.

Uranium 233 & 234	3E-08
Uranium 235	3E-08
Uranium 238	3E-08
Americium 241	5E-08
Plutonium 239 & 240	5E-08
Tritium (g _s)**	1E-13
Strontium 89	4E-12
Strontium 90	7E-11
Cesium 137	6E-11
Radium 226	4E-09
Radium 228	8E-10

Dose/Risk Estimates - Non - Radionuclides

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	1.47E-07
Intake/Exposure Period	mg	1.28E-03
Carcinogen Dose Rate	mg/kg/day	7.18E-10
Non - Carc. Dose Rate	mg/kg/day	1.01E-08

EPA L.E.C.R.

Arsenic	4E-08
Beryllium	6E-09
Cadmium	4E-09
Chromium VI	3E-09
a - Hexachlorocyclohexane	5E-09
B - Hexachlorocyclohexane	1E-09
Heptachlor	3E-09
Heptachlor Epoxide	7E-09
Aldrin	1E-08
Dieldrin	1E-09
DDT	2E-10
Chlordane (alpha, gamma)	9E-10
Toxaphene	8E-10

Hazard Quotient

Barium	1E-05
Chromium III	2E-03
Chromium VI	2E-03
Manganese	9E-05
Mercury	1E-04

Dose/Risk Estimates - VOCs

Variable	Unit	Parameter
Intake Rate	m ³ /hr	1.2
Intake Duration	hr/day	10
Exposure Period	Days	1825
Fract. Leeward Wind Factor		0.4
Intake Concentration	mg/m ³	0.00E+00
Intake/Exposure Period	mg	0.00E+00
Carcinogen Dose Rate	mg/kg/day	0.00E+00
Non - Carc. Dose Rate	mg/kg/day	0.00E+00

EPA L.E.C.R.

Chloroform	0E+00
Carbon Tetrachloride	0E+00
Benzene	0E+00
Dichloromethane	0E+00
1,2-Dichloroethane	0E+00
1,1-Dichloroethene	0E+00
1,3-Dichloropropene	0E+00
1,1,2-Trichloroethane	0E+00
Bromoform	0E+00
Tetrachloroethene	0E+00
Styrene	0E+00
Vinyl Chloride	0E+00
1,2-Dichloroethane	0E+00
1,2-Dichloropropane	0E+00
1,1,2,2-Tetrachloroethane	0E+00
2-Chloroethyl Ether	0E+00
Hexachlorethane	0E+00
Hexachlorobutadiene	0E+00
2,4,6-Trichlorophenol	0E+00
Hexachlorobenzene	0E+00

Hazard Quotient

1,1,1-Trichloroethane	0E+00
Toluene	0E+00
Dichloromethane	0E+00
Xylenes	0E+00
MEK	0E+00
Bromomethane	0E+00
Carbon Disulfide	0E+00
1,1-Dichloroethane	0E+00
Vinyl Acetate	0E+00
1,3-Dichloropropene	0E+00
Chlorobenzene	0E+00
Ethylbenzene	0E+00
1,4-Dichlorobenzene	0E+00
1,2-Dichlorobenzene	0E+00
Nitrobenzene	0E+00
1,2,4-Trichlorobenzene	0E+00
Hexachlorocyclopentadiene	0E+00

Vehicle Traffic - Heavy (100 VKT/Day) - OU3
EPA Threshold Levels

	L.E.C.R Threshold Conc.	HI Threshold Conc.
Radionuclides		
	pCi/g	
Uranium 233 & 234	2.88E+01	
Uranium 235	3.11E+01	
Uranium 238	3.24E+01	
Americium 241	1.95E+01	
Plutonium 239 & 240	1.90E+01	
Tritium (gas)**	9.98E+06	
Strontium 89	2.68E+05	
Strontium 90	1.39E+04	
Cesium 137	1.59E+04	
Radium 226	2.60E+02	
Radium 228	1.20E+03	
Non - Radionuclides		
	ug/g	ug/g
Arsenic	2.79E+01	
Barium		9.95E+03
Beryllium	1.66E+02	
Cadmium	2.28E+02	
Chromium III		5.67E+01
Chromium VI	3.40E+02	5.67E+01
Manganese		1.13E+03
Mercury		8.55E+02
Hexachlorocyclohexane (alpha)	2.21E+02	
Hexachlorocyclohexane (beta)	7.74E+02	
Heptachlor	3.09E+02	
Heptachlor Epoxide	1.53E+02	
Aldrin	8.19E+01	
Dieldrin	8.70E+02	
DDT	4.10E+03	
Chlordane (alpha, gamma)	1.07E+03	
Toxaphene	1.27E+03	
VOCs & Semi-VOCs		
	ug/g	ug/g
Chloroform	N/A	N/A
1,1,1-Trichloroethane	N/A	N/A
Carbon Tetrachloride	N/A	N/A
Benzene	N/A	N/A
Toluene	N/A	N/A
Dichloromethane	N/A	N/A
Xylenes	N/A	N/A
MEK	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Bromomethane	N/A	N/A
Carbon Disulfide	N/A	N/A
1,1-Dichloroethene	N/A	N/A
1,1-Dichloroethane	N/A	N/A
Vinyl Acetate	N/A	N/A
1,3-Dichloropropene	N/A	N/A
1,1,2-Trichloroethane	N/A	N/A
Bromoform	N/A	N/A
Tetrachloroethene	N/A	N/A
Chlorobenzene	N/A	N/A
Ethylbenzene	N/A	N/A
Styrene	N/A	N/A
Vinyl Chloride	N/A	N/A
1,2-Dichloroethane	N/A	N/A
1,2-Dichloropropane	N/A	N/A
1,1,2,2-Tetrachloroethane	N/A	N/A
2-Chloroethyl Ether	N/A	N/A
1,4-Dichlorobenzene	N/A	N/A
1,2-Dichlorobenzene	N/A	N/A
Nitrobenzene	N/A	N/A
Hexachloroethane	N/A	N/A
1,2,4-Trichlorobenzene	N/A	N/A
Hexachlorobutadiene	N/A	N/A
Hexachlorocyclopentadiene	N/A	N/A
2,4,6-Trichlorophenol	N/A	N/A
Hexachlorobenzene	N/A	N/A

APPENDIX 4
RISK CALCULATIONS

A.4.1 INTRODUCTION

The calculation of potential risks to human health involves combining the results of the toxicity and exposure assessments. This provides numerical quantification relative to the existence and magnitude of potential public health concerns related to contamination generated by selected site remedial activities. These numerical estimates are comparisons of exposure levels with appropriate toxicity criteria (reference concentrations or doses) or estimates of the lifetime cancer risks associated with a particular intake. Risk characterization also considers the nature and weight of evidence supporting these risk estimates. Potential risks for human health were calculated based on four "source to receptor" distances for the activities discussed in Appendix 2. The sections that follow describe the calculation of contaminant intakes, their respective health impacts, and the methodology employed to accommodate contribution from multiple contaminants and sites.

A.4.2 CALCULATION OF CONTAMINANT INTAKES

The calculation of contaminant intakes consists of estimating the magnitude, frequency, duration, and route of exposure of contaminants to humans. The magnitude of exposure is typically determined by measuring or estimating the amount of a chemical available at "exchange boundaries" (e.g., the lungs) during some specified time. Contact with the chemical may lead to absorption. The magnitude of total absorption is a critical variable for the calculation of health risks.

Environmental fate and transport modeling was used to estimate chemical concentrations in air at the point of contact with each receptor (see Appendix 3). Contaminant exposure is expressed in terms of intake and defined as the amount of a substance taken into the body per unit body weight per unit time. All non-radiological intakes are expressed in units of milligram of contaminant per kilogram of body weight per day (mg/kg/day). Radiological intake and exposure is expressed

in total picocuries (pCi) inhaled. The receptor parameters used to evaluate the intake of contaminants are shown in Table A.4-1. These values are representative of an adult receptor located at the boundary of the Rocky Flats Plant. An example of how these parameters are incorporated in the derivation of soil threshold levels is given in Appendix 5.

**TABLE A.4-1
RECEPTOR PARAMETERS USED TO CALCULATE
CONTAMINANT INTAKES**

Parameter	Value	Units	Reference
Breathing Rate	1.2	m ³ /hr	EPA, 1989
Intake Duration	10	hr/day	Maximum daily duration of remedial activities
Exposure Period	1825	days	Total number of days in which exposures occur
Fractional Leeward Wind Factor	0.4	unitless	Rocky Flats Environmental Report for 1989. EG&G
Averaging Time for Noncarcinogenic Chemicals	5	years	Assumed calendar period of exposure based on current scenarios
Averaging Time for Carcinogenic Chemicals	70	years	EPA, 1989

A.4.3 RECEPTOR IMPACTS

Health risks from inhalation exposure are calculated by combining the chemical intake information with numerical indicators of toxicity. Toxicity assessment is the process of characterizing the relationship between the dose or intake of a substance and the potential for an adverse effect in the exposed population. Toxicity evaluation is divided into two general classes for purposes of establishing quantitative indicators of toxicity: noncarcinogens and potential carcinogens.

A.4.3.1 Carcinogenic Impacts

Carcinogenic impacts were calculated for each of the principal contaminants identified in Appendix 1, using the unit concentrations of PCs at the receptor computed in Appendix 3, the intake parameters shown in Table A.4-1 and the cancer potency slope factors shown in Table A.4-2.

Numerical estimates of cancer potency of hazardous chemicals are presented as slope factors (SFs). Under the assumption of dose-response linearity at low doses, the SF defines the cancer risk (excess chance of causing cancer over a lifetime) due to continuous lifetime exposure to one unit of carcinogen (in units of risk per mg/kg/day). Likewise the radiological SF defines cancer risk per unit intake of a radionuclide (in units of risk per pCi). Calculation of cancer risk provides an upper-bound estimate of health effects. Individual cancer risk has been calculated as the product of exposure to a chemical (in mg/kg/day) or radionuclide (in pCi) and the SF for that substance (in $(\text{mg/kg/day})^{-1}$ or $(\text{pCi})^{-1}$). Separate estimates of cancer risk are calculated for each of the PCs. Each of these cancer risks are related to the contaminant emissions from a unit concentration of that contaminant in soil during a specific and discrete site activity.

Table A.4-2
Slope Factors and Reference Doses for Principal Contaminants

Principal Contaminants (PCs)	L.E.C.R Slope Factors (PC1) ^ -1	HI Inh. RfC (mg/kg/day)
Radionuclides		
Uranium 233 & 234	2.70E-08	
Uranium 235	2.50E-08	
Uranium 238	2.40E-08	
Americium 241	4.00E-08	
Plutonium 239 & 240	4.10E-08	
Tritium	7.80E-14	
Strontium 89	2.90E-12	
Strontium 90	5.60E-11	
Cesium 137	4.90E-11	
Radium 226	3.00E-09	
Radium 228	6.50E-10	
Non-Radionuclides	(mg/kg/day) ^ -1	(mg/kg/day)
Arsenic	5.00E+01	
Barium		1.00E-03
Beryllium	8.40E+00	
Cadmium	6.10E+00	
Chromium III		5.70E-06
Chromium VI	4.10E+00	5.70E-06
Manganese		1.14E-04
Mercury		8.60E-05
Hexachlorocyclohexane (alpha)	6.30E+00	
Hexachlorocyclohexane (beta)	1.80E+00	
Heptachlor	4.50E+00	
Heptachlor Epoxide	9.10E+00	
Aldrin	1.70E+01	
Dieldrin	1.60E+00	
DDT	3.40E-01	
Chlordane (alpha, gamma)	1.30E+00	
Toxaphene	1.10E+00	
VOCs & Semi-VOCs		
Chloroform	8.10E-02	
1,1,1-Trichloroethane		3.00E+00
Carbon Tetrachloride	1.30E-01	
Benzene	3.00E-02	
Toluene		6.00E-01
Dichloromethane	2.00E-03	9.00E-01
Xylenes		9.00E-02
MEK		9.00E-01
1,2-Dichloroethane	9.10E-02	
Bromomethane		2.00E-02
Carbon Disulfide		3.00E-03
1,1-Dichloroethene	1.20E+00	
1,1-Dichloroethane		1.00E+00
Vinyl Acetate		6.00E-02
1,3-Dichloropropene	1.30E-01	6.00E-03
1,1,2-Trichloroethane	5.70E-02	
Bromoform	3.90E-03	
Tetrachloroethene	1.80E-03	
Chlorobenzene		5.00E-02
Ethylbenzene		3.00E-01
Styrene	2.00E-03	
Vinyl Chloride	2.90E-02	
1,2-Dichloroethane	9.10E-02	
1,2-Dichloropropane	1.30E-01	
1,1,2,2-Tetrachloroethane	2.00E-01	
2-Chloroethyl Ether	1.10E+00	
1,4-Dichlorobenzene		2.00E-01
1,2-Dichlorobenzene		4.00E-01
Nitrobenzene		6.00E-03
Hexachloroethane	1.40E-02	
1,2,4-Trichlorobenzene		3.00E-02
Hexachlorobutadiene	7.80E-02	
Hexachlorocyclopentadiene		2.00E-04
2,4,6-Trichlorophenol	1.10E-02	
Hexachlorobenzene	1.60E+00	

A.4.3.2 Noncarcinogenic Impacts

Non-carcinogenic impacts were calculated using the unit concentrations of PCs at the receptor computed in Appendix 3, the intake parameters shown in Table A.4-1, and the reference doses shown on Table A.4-2. Numerical estimates of noncarcinogenic toxicity are presented as reference doses (RfD). The RfD is based on the assumption that thresholds exist for certain noncancerous toxic effects (such as cellular necrosis), but may not exist for other health effects such as cancer. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure.

The calculated intake is divided by the RfD to yield the hazard index (HI). If the estimated daily intake for any single chemical is greater than the RfD, the HI will exceed unity indicating the potential for health effects. Separate hazard indices are derived for each of the chemicals of concern. Each of these hazard indices are related to the contaminant emissions from a unit concentration of a contaminant in soil during a specific and discrete site activity.

A.4.4 MULTIPLE CONTAMINANT/SITE APPROACH

In calculating soil threshold concentrations based on inhalation risk, a consistent approach has been adopted to accommodate the potential for risk contribution from multiple contaminants and/or multiple sites. The goal is to calculate soil threshold concentrations which can be implemented without regard to the number of contaminants involved or cognizance of concurrent activities at other operable units. In order to achieve this goal, a level of conservatism has been introduced to the process.

For non-carcinogenic contaminants, individual soil threshold values are calculated to yield a hazard index of 0.1. As stated in the National Contingency Plan (40 CFR Part 300), "For systemic toxicants, acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety." A hazard index of 0.1 is a factor of ten below the level which has the potential for adverse toxicological impacts. A factor of ten is believed to be an adequate margin of safety.

For carcinogenic contaminants, individual soil threshold values are calculated to yield a carcinogenic risk of 10^{-6} . As stated in 40 CFR Part 300, "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for. . . multiple contaminants at a site or multiple pathways of exposure."

Two other sources of guidance are potentially relevant for determining a specified lifetime excess cancer risk. These are:

The National Oil and Hazardous Substances Pollution Contingency: Plan Final Rule (FR 8667, March 8, 1990, a.k.a the National Contingency Plan [NCP]) guides EPA to consider a range between 10^{-4} and 10^{-6} as an acceptable lifetime excess cancer risk (LECR) under CERCLA.

OSWER Directive 9360.1-01, Interim Final Guidance on Removal Action Levels at Contaminated Drinking Water Sites (EPA, October 1987) guides EPA to consider an LECR of 10^{-4} as the benchmark at which the Agency is required to provide an alternate water supply.

Therefore, calculation of soil threshold concentrations at a hazard index of 0.1 or the 10^{-6} risk level is adequately health protective to accommodate the potential for risk contribution from multiple contaminants and/or multiple sites.

A.4.5 UNCERTAINTIES AND IMPACTS ON RISK CALCULATIONS

Besides the possibility of contributions from multiple sites and/or contaminants, there are other sources of uncertainty in the risk based derivation of the soil threshold levels. These uncertainties have been taken into consideration by maximizing the potential impacts, rather than assuming an average impact.

The sources of emissions (i.e., from excavation, drilling, vehicular traffic) where calculated assuming maximum probable parameters. For example, vehicle weight used in the formula to estimate emissions from light or heavy traffic is assumed to be at maximum loading. However, the vehicle may not always be carrying a full load, thus reducing the actual amount of dust emitted (and therefore, the off-site contaminant concentrations).

The activities (and intakes) are assumed to take place 10 hours a day every day for five years. It is more likely that the work will occur over a fraction of this period. In addition, different activities at each site (such as excavation and vehicular traffic) will result in different rates of emission. However, the soil threshold limit will be selected based on the activity emitting the most dust.

The dispersion formula used to estimate the transport of contaminants to the receptor is conservative since it does not take into account deposition of particulates from the plume or other contaminant removal mechanisms. In addition, the distance to the receptor will in most cases be underestimated, resulting in an overestimate of the concentration at the receptor location.

The potential receptor is assumed to be at the site boundary at all times during which the work activities are occurring (every day for five years). The exposure scenario does not take into consideration the fact that the receptor may not always remain at the same location. The receptor may be indoors, away from home, or may have relocated permanently during the five year period.

All potential carcinogens are treated as known (Group A) human carcinogens, whereas many are actually lower rank carcinogens which have been shown to cause cancer in animals but not in humans. It is possible that some of these are not human carcinogens. Non-carcinogens are assumed to affect the same organs for additivity. However, an organ affected by one substance may not be affected by a different substance.

All the above considerations compound the margin of safety inherent in the assumptions made in Section A.4.4. Therefore, it is very likely that the risks from the activities considered in this PPCD will be significantly lower than the levels that form the basis for the soil threshold levels.

A.4.6 REFERENCES

EPA, 1989. Risk Assessment Guidance for Superfund - Human Health Evaluation Manual, Part A, Interim Final. OSWER Directive 9285.701A, Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., December, 1989.

EG&G Rocky Flats, Inc., 1989. Rocky Flats Environmental Report for 1989.

40 CFR 300, U.S. Code of Federal Regulations, Title 40 Part 300, "National Oil and Hazardous Substances Pollution Contingency Plan." U.S. Environmental Protection Agency, 1990.

APPENDIX 5

CALCULATION OF SOIL THRESHOLD LEVELS

A.5.1 INTRODUCTION

Soil threshold levels have been calculated for each of the principal contaminants (PCs) that were screened in Appendix 1 and for each of four receptor distances. The calculation of soil threshold levels involves a correlation of emission factors and atmospheric dispersion with the risk values established in Appendix 4.

A.5.2 DOSIMETRIC/RISK PERFORMANCE OBJECTIVE

Calculation of soil threshold levels requires the selection of a risk-based performance objective which is acceptable considering potential contributions from multiple contaminants and/or multiple sites. As discussed in Appendix 4, soil threshold concentrations have been calculated at a hazard index of 0.1 or the 10^{-6} risk level to the public.

A.5.3 CALCULATION OF SOIL THRESHOLD CONCENTRATIONS

The calculation of soil threshold concentration uses the receptor risk values calculated in Appendix 4, normalized to the 0.1 hazard index or 10^{-6} risk level. These soil threshold levels take into account the different emission rates resulting from the various activities considered (drilling, excavation, traffic, etc.). These threshold levels also take into account the dilution in airborne concentrations from the source to the receptor by application of Turner's equation for atmospheric dispersion. This is done by back-calculating from the end result (limiting off-site airborne concentrations) to the source of this concentration (emission of contaminated soil by mechanical activity). Back-calculation is commonly employed in the CERCLA/SARA and RCRA process for establishing acceptable concentrations of contaminants in virtually all media. The technique is also widely used in other environmental-regulatory programs (NESHAPS, establishing discharge limits under NPDES regulations, etc.). This technique can best be illustrated by the following example.

A.5.4 EXAMPLE OF CALCULATION

The first step in the calculation of soil threshold levels begins with an assessment of the concentration of the contaminant in air that would result in a lifetime excess cancer risk (LECR) of 10^{-6} for carcinogens or a Hazard Index of 0.1 for non-carcinogens. Since the majority of the principal contaminants are carcinogens, the example will be based on beryllium. The major difference between carcinogens and non-carcinogens is that the risk is spread out over 70 years for the former, but the dose is distributed over 5 years (the period of work activities assumed in the PPCD) for the latter.

From Table A.4-2, the slope factor for beryllium is listed as 8.4 per mg/kg/day. For a 70 kg individual, this converts to 0.12 per mg/day. Therefore, the individual cannot inhale more than 8.3×10^{-6} mg/day for the LECR not to exceed 10^{-6} . The exposure is assumed to occur over 5 years (or 1825 days), but the risk is averaged over 70 years resulting in a total limiting inhaled mass of 0.21 mg beryllium. From Table A.4-1, the receptor is assumed to inhale $1.2 \text{ m}^3/\text{hr}$ of air during the exposure period (10 hr/day for 1825 days), for a total of $22,000 \text{ m}^3$. However, the wind is assumed to blow in the direction of the receptor 40 percent of the time. Thus, the volume of potentially contaminated air inhaled by the receptor is assumed to be $8,800 \text{ m}^3$. Therefore, the average concentration of beryllium in this air must not exceed $2.4 \times 10^{-5} \text{ mg/m}^3$. This is the number listed in Table A.7-3 for beryllium and does not depend on the location or type of activity that results in this release.

To assess the release rate of beryllium that would result in the above concentration at the receptor location, atmospheric dispersion must be taken into account. In this example, it is assumed that the activity causing the release occurs in Zone B, assumed to be 2.9 km from the receptor location on the site boundary. The lateral and vertical dispersion factors for Turner's Equation are 182 m and 64 m, respectively (Table A.3-1). The average windspeed was estimated to be 4.7 m/sec.

These factors are multiplied together with the number pi to obtain $1.7 \times 10^5 \text{ m}^3/\text{sec}$ (see Turner's Equation, Section A.3.2 in Appendix 3). This number is then multiplied by the limiting concentration, $2.4 \times 10^{-5} \text{ mg/m}^3$, to obtain the maximum allowable release rate of the contaminant, 4.2 mg/sec (or $4200 \text{ } \mu\text{g/sec}$).

Assuming that the activity under consideration is drilling, the estimated release rate of dust is 0.25 kg per well over 10 hours (see Section A.2.2 in Appendix 2). Converting to seconds and grams, this is 0.007 g/sec of dust.

The beryllium soil threshold level for drilling in Zone B is obtained by dividing the limiting contaminant release rate by the estimated dust emission rate. In this example, the result is $6 \times 10^5 \text{ } \mu\text{g/g}$ as shown in the Zone B Table in Attachment A.5.1.

Similar mathematics are involved in deriving all the other soil threshold levels for each contaminant, activity and zone considered.

A.5.5 TABULATION OF SOIL THRESHOLD LEVELS

The calculated threshold soil concentration for each of the receptor distances (0.5 km , 1.6 km , 2.9 km and 4.4 km , corresponding to Zones A, B, C, and OU-3, respectively) are shown in Attachment A.5.1. The tables in this attachment summarize the soil threshold levels calculated based on the activities described in Appendix 2. The actual calculations were performed as part of the Zones A, B and C and Operable Unit 3 calculations in Appendix 3. For chemicals with both carcinogenic and noncarcinogenic quantified threshold calculations, the more limiting (lower concentration) will be applied. Threshold values exceeding $10^6 \text{ } \mu\text{g/g}$ indicate that under the assumed site conditions (i.e., nature of activity, soil moisture, wind speed, etc.), the benchmark risk to an off-site receptor will never be exceeded. This

is due to the fact that the concentration of a contaminant is unable to exceed 10^6 $\mu\text{g/g}$; thus, the soil threshold level will not be reached.

ATTACHMENT A.5.1

**SOIL THRESHOLD LEVELS -
ZONES A, B, C & OU3**

Summary of Calculations in
Attachments A.3.3 through A.3.6 to Appendix 3

SOIL THRESHOLD LEVELS – ZONE A

PCs	ACTIVITY							
	DRILLING	VEHICLE TRAFFIC (LIGHT)	VEHICLE TRAFFIC (HEAVY)	MINOR EXCAVATIONS (TEST PIT)	REMOVAL BY SCRAPER	MAJOR EXCAVATIONS UNLOADING BY SCRAPER	TRANS. BY SCRAPER	FRONT-SHOVEL OPS
Radionuclides, pCi/g								
Uranium 233 & 234	4.25E+04	1.12E+03	1.12E+02	2.23E+07	2.67E+03	2.72E+05	1.26E+01	N/A
Uranium 235	4.39E+04	1.21E+03	1.21E+02	2.41E+07	2.88E+03	2.94E+05	1.36E+01	N/A
Uranium 238	4.78E+04	1.26E+03	1.26E+02	2.51E+07	3.01E+03	3.06E+05	1.42E+01	N/A
Americium 241	2.87E+04	7.57E+02	7.57E+01	1.51E+07	1.80E+03	1.84E+05	8.51E+00	N/A
Plutonium 239 & 240	2.80E+04	7.38E+02	7.38E+01	1.47E+07	1.76E+03	1.79E+05	8.31E+00	N/A
Tritium (gas)**	1.47E+10	3.88E+08	3.88E+07	7.74E+12	9.25E+08	9.41E+10	4.37E+06	N/A
Strontium 89	3.96E+08	1.04E+07	1.04E+06	2.08E+11	2.49E+07	2.53E+09	1.17E+05	N/A
Strontium 90	2.05E+07	5.40E+05	5.40E+04	1.08E+10	1.29E+06	1.31E+08	6.08E+03	N/A
Cesium 137	2.34E+07	6.18E+05	6.18E+04	1.23E+10	1.47E+06	1.50E+08	6.95E+03	N/A
Radium 226	3.82E+05	1.01E+04	1.01E+03	2.01E+08	2.40E+04	2.45E+06	1.14E+02	N/A
Radium 228	1.77E+06	4.66E+04	4.66E+03	9.28E+08	1.11E+05	1.13E+07	5.24E+02	N/A
Non-Radionuclides, ug/g								
Arsenic	4.10E+04	1.08E+03	1.08E+02	2.69E+06	2.63E+03	1.31E+05	2.45E+01	9.80E+03
Barium	1.47E+07	3.87E+05	3.87E+04	9.60E+08	4.61E+05	4.69E+07	8.74E+03	3.50E+06
Beryllium	2.44E+05	6.44E+03	6.44E+02	1.60E+07	7.68E+03	7.82E+05	1.46E+02	5.83E+04
Cadmium	3.36E+05	8.87E+03	8.87E+02	2.20E+07	1.06E+04	1.08E+06	2.01E+02	8.03E+04
Chromium III	8.36E+04	2.20E+03	2.20E+02	5.47E+06	2.63E+03	2.67E+05	4.98E+01	1.99E+04
Chromium VI	8.36E+04	2.20E+03	2.20E+02	5.47E+06	2.63E+03	4.98E+01	4.98E+01	1.99E+04
Manganese	1.67E+06	4.41E+04	4.41E+03	1.09E+08	5.25E+04	5.35E+06	9.97E+02	3.99E+05
Mercury	1.26E+06	3.32E+04	3.32E+03	8.26E+07	3.96E+04	4.03E+06	7.52E+02	3.01E+05
Hexachlorocyclohexane (alpha)	3.26E+05	8.59E+03	8.59E+02	2.13E+07	1.02E+04	1.04E+06	1.94E+02	7.78E+04
Hexachlorocyclohexane (beta)	1.14E+06	3.01E+04	3.01E+03	7.47E+07	3.38E+04	3.65E+06	6.80E+02	2.72E+05
Heptachlor	4.56E+05	1.20E+04	1.20E+03	2.99E+07	1.43E+04	1.46E+06	2.72E+02	1.09E+05
Heptachlor Epoxide	2.26E+05	5.95E+03	5.95E+02	1.48E+07	7.09E+03	7.21E+05	1.34E+02	5.38E+04
Aldrin	1.21E+05	3.18E+03	3.18E+02	7.91E+06	3.79E+03	3.86E+05	7.20E+01	2.88E+04
Dieldrin	1.28E+06	3.38E+04	3.38E+03	8.40E+07	4.03E+04	4.10E+06	7.65E+02	3.06E+05
DDT	6.04E+06	1.59E+05	1.59E+04	3.95E+08	1.90E+05	1.93E+07	3.60E+03	1.44E+06
Chlordane (alpha, gamma)	1.58E+06	4.16E+04	4.16E+03	1.03E+08	4.96E+04	5.05E+06	9.41E+02	3.77E+05
Toxaphene	1.87E+06	4.92E+04	4.92E+03	1.22E+08	5.86E+04	5.97E+06	1.11E+03	4.45E+05
VOCs & Semi-VOCs, ug/g								
Chloroform	1.49E+04	N/A	N/A	1.07E+03	1.51E+01	N/A	N/A	3.27E+00
1,1,1-Trichloroethane	2.59E+07	N/A	N/A	1.86E+06	2.63E+04	N/A	N/A	5.67E+03
Carbon Tetrachloride	9.31E+03	N/A	N/A	6.66E+02	9.43E+00	N/A	N/A	2.03E+00
Benzene	4.03E+04	N/A	N/A	2.99E+02	4.08E+01	N/A	N/A	8.87E+00
Toluene	5.19E+06	N/A	N/A	3.71E+05	5.25E+03	N/A	N/A	1.13E+03
Dichloromethane	6.05E+05	N/A	N/A	4.33E+05	6.13E+02	N/A	N/A	1.32E+02
Xylenes	7.78E+05	N/A	N/A	5.57E+04	7.88E+02	N/A	N/A	1.70E+02
MEK	7.78E+06	N/A	N/A	5.57E+05	7.88E+03	N/A	N/A	1.70E+03
1,2-Dichloroethane	1.33E+04	N/A	N/A	9.52E+02	1.35E+01	N/A	N/A	2.91E+00
Bromomethane	1.73E+05	N/A	N/A	1.24E+05	1.75E+02	N/A	N/A	3.78E+01
Carbon Disulfide	2.59E+04	N/A	N/A	1.86E+03	2.63E+01	N/A	N/A	5.67E+00
1,1-Dichloroethene	1.01E+03	N/A	N/A	7.22E+01	1.02E+00	N/A	N/A	2.20E-01
1,1-Dichloroethane	8.65E+06	N/A	N/A	6.19E+05	8.75E+03	N/A	N/A	1.89E+03
Vinyl Acetate	5.19E+05	N/A	N/A	3.71E+04	5.25E+02	N/A	N/A	1.13E+02
1,3-Dichloropropene	9.31E+03	N/A	N/A	6.66E+02	9.43E+00	N/A	N/A	2.03E+00
1,1,2-Trichloroethane	2.12E+04	N/A	N/A	1.52E+03	2.13E+01	N/A	N/A	4.64E+00
Bromoform	3.10E+05	N/A	N/A	2.22E+04	3.14E+02	N/A	N/A	6.78E+01
Tetrachloroethene	6.05E+05	N/A	N/A	4.81E+03	6.84E+02	N/A	N/A	1.47E+02
Chlorobenzene	4.32E+05	N/A	N/A	3.09E+04	4.38E+02	N/A	N/A	9.45E+01
Ethylbenzene	2.59E+06	N/A	N/A	1.86E+05	2.63E+03	N/A	N/A	5.67E+02
Styrene	6.05E+05	N/A	N/A	2.89E+03	6.13E+02	N/A	N/A	1.32E+02
Vinyl Chloride	4.17E+04	N/A	N/A	2.99E+03	4.23E+01	N/A	N/A	9.12E+00
1,2-Dichloroethane	1.33E+04	N/A	N/A	9.52E+02	1.35E+01	N/A	N/A	2.91E+00
1,2-Dichloropropane	9.31E+03	N/A	N/A	6.66E+02	9.43E+00	N/A	N/A	2.03E+00
1,1,2,2-Tetrachloroethane	6.05E+03	N/A	N/A	4.33E+02	6.13E+00	N/A	N/A	1.32E+00
2-Chloroethyl Ether	1.10E+03	N/A	N/A	7.87E+01	1.11E+00	N/A	N/A	2.40E-01
1,4-Dichlorobenzene	1.73E+06	N/A	N/A	4.33E+05	1.75E+03	N/A	N/A	3.78E+02
1,2-Dichlorobenzene	3.46E+06	N/A	N/A	1.24E+06	3.50E+03	N/A	N/A	7.56E+02
Nitrobenzene	5.19E+04	N/A	N/A	1.24E+04	5.25E+01	N/A	N/A	1.13E+01
Hexachloroethane	8.65E+04	N/A	N/A	6.19E+03	8.75E+01	N/A	N/A	1.89E+01
1,2,4-Trichlorobenzene	2.59E+05	N/A	N/A	1.86E+04	2.63E+02	N/A	N/A	5.67E+01
Hexachlorobutadiene	1.55E+04	N/A	N/A	1.11E+03	1.57E+01	N/A	N/A	3.39E+00
Hexachlorocyclopentadiene	1.73E+03	N/A	N/A	4.33E+02	1.75E+00	N/A	N/A	3.78E-01
2,4,6-Trichlorophenol	1.10E+05	N/A	N/A	7.87E+03	1.11E+02	N/A	N/A	2.40E+01
Hexachlorobenzene	7.56E+02	N/A	N/A	5.41E+01	7.66E-01	N/A	N/A	1.65E-01

NOTE: Threshold values exceeding 1E06 ug/g indicate that under the assumed site conditions (i.e., nature of activity, soil moisture, wind speed, etc.), the acceptable risk to an off-site receptor will never be exceeded. This is due to the fact that the concentration of a contaminant can never exceed 1E06 ug/g; thus, the soil threshold level will never be reached.

SOIL THRESHOLD LEVELS – ZONE B

PCs	ACTIVITY							
	DRILLING	VEHICLE TRAFFIC (LIGHT)	VEHICLE TRAFFIC (HEAVY)	MINOR EXCAVATIONS (TEST PIT)	REMOVAL BY SCRAPER	MAJOR EXCAVATIONS UNLOADING BY SCRAPER	TRANS. BY SCRAPER	FRONT-SHOVEL OPS
Radionuclides, pCi/g								
Uranium 233 & 234	1.04E+05	2.76E+03	2.76E+02	5.51E+07	6.58E+03	6.70E+05	3.11E+01	N/A
Uranium 235	1.12E+05	2.98E+03	2.98E+02	5.96E+07	7.10E+03	7.23E+05	3.35E+01	N/A
Uranium 238	1.16E+05	3.11E+03	3.11E+02	6.20E+07	7.40E+03	7.53E+05	3.49E+01	N/A
Americium 241	6.99E+04	1.86E+03	1.86E+02	3.72E+07	4.44E+03	4.52E+05	2.10E+01	N/A
Plutonium 239 & 240	6.82E+04	1.82E+03	1.82E+02	3.63E+07	4.33E+03	4.41E+05	2.05E+01	N/A
Tritium (gas)**	3.58E+10	9.55E+08	9.55E+07	1.91E+13	2.28E+09	2.32E+11	1.08E+07	N/A
Strontium 89	9.64E+08	2.57E+07	2.57E+06	5.13E+11	6.12E+07	6.23E+09	2.89E+05	N/A
Strontium 90	4.99E+07	1.33E+06	1.33E+05	2.66E+10	3.17E+06	3.23E+08	1.50E+04	N/A
Cesium 137	5.70E+07	1.52E+06	1.52E+05	3.04E+10	3.62E+06	3.69E+08	1.71E+04	N/A
Radium 226	9.32E+05	2.48E+04	2.48E+03	4.96E+08	5.92E+04	6.03E+06	2.80E+02	N/A
Radium 228	4.30E+06	1.15E+05	1.15E+04	2.29E+09	2.73E+05	2.78E+07	1.29E+03	N/A
Non-Radionuclides, ug/g								
Arsenic	1.00E+05	2.67E+03	2.67E+02	6.64E+06	3.18E+03	3.23E+05	6.03E+01	2.41E+04
Barium	3.57E+07	9.52E+05	9.52E+04	2.37E+09	1.13E+06	1.15E+08	2.15E+04	8.62E+06
Beryllium	5.95E+05	1.59E+04	1.59E+03	3.95E+07	1.89E+04	1.92E+06	3.59E+02	1.44E+05
Cadmium	8.19E+05	2.18E+04	2.18E+03	5.44E+07	2.60E+04	2.65E+06	4.94E+02	1.98E+05
Chromium III	2.04E+05	5.43E+03	5.43E+02	1.35E+07	6.47E+03	6.58E+05	1.23E+02	4.91E+04
Chromium VI	2.04E+05	5.43E+03	5.43E+02	1.35E+07	6.47E+03	6.58E+05	1.23E+02	4.91E+04
Manganese	4.07E+06	1.09E+05	1.09E+04	2.70E+08	1.29E+05	1.32E+07	2.45E+03	9.83E+05
Mercury	3.07E+06	8.19E+04	8.19E+03	2.04E+08	9.76E+04	9.93E+06	1.85E+03	7.41E+05
Hexachlorocyclohexane (alpha)	7.93E+05	2.12E+04	2.12E+03	5.27E+07	2.52E+04	2.57E+06	4.78E+02	1.92E+05
Hexachlorocyclohexane (beta)	2.78E+06	7.40E+04	7.40E+03	1.84E+08	8.82E+04	8.98E+06	1.67E+03	6.70E+05
Heptachlor	1.11E+06	2.96E+04	2.96E+03	7.37E+07	3.53E+04	3.59E+06	6.70E+02	2.68E+05
Heptachlor Epoxide	5.49E+05	1.46E+04	1.46E+03	3.65E+07	1.75E+04	1.78E+06	3.31E+02	1.33E+05
Aldrin	2.94E+05	7.84E+03	7.84E+02	1.95E+07	9.34E+03	9.51E+05	1.77E+02	7.10E+04
Dieldrin	3.12E+06	8.33E+04	8.33E+03	2.07E+08	9.93E+04	1.01E+07	1.88E+03	7.54E+05
DDT	1.47E+07	3.92E+05	3.92E+04	9.76E+08	4.67E+05	4.67E+07	8.86E+03	3.55E+06
Chlordane (alpha, gamma)	3.84E+06	1.03E+05	1.03E+04	2.55E+08	1.22E+05	1.24E+07	2.32E+03	9.28E+05
Toxaphene	4.54E+06	1.21E+05	1.21E+04	3.02E+08	1.44E+05	1.47E+07	2.74E+03	1.10E+06
VOCs & Semi-VOCs, ug/g								
Chloroform	3.64E+04	N/A	N/A	2.63E+03	3.73E+01	N/A	N/A	8.04E+00
1,1,1-Trichloroethane	6.32E+07	N/A	N/A	4.57E+06	6.47E+04	N/A	N/A	1.40E+04
Carbon Tetrachloride	2.27E+04	N/A	N/A	1.64E+03	2.32E+01	N/A	N/A	5.01E+00
Benzene	9.83E+04	N/A	N/A	7.11E+03	1.29E+04	N/A	N/A	2.17E+01
Toluene	1.26E+07	N/A	N/A	9.14E+05	1.29E+04	N/A	N/A	2.79E+03
Dichloromethane	1.47E+06	N/A	N/A	1.07E+05	1.51E+03	N/A	N/A	3.26E+02
Xylenes	1.90E+06	N/A	N/A	1.37E+05	1.94E+03	N/A	N/A	4.19E+02
MEK	1.90E+07	N/A	N/A	1.37E+06	1.94E+04	N/A	N/A	4.19E+03
1,2-Dichloroethane	3.24E+04	N/A	N/A	2.34E+03	3.32E+01	N/A	N/A	7.16E+00
Bromomethane	4.21E+05	N/A	N/A	3.05E+04	4.31E+02	N/A	N/A	9.30E+01
Carbon Disulfide	6.32E+04	N/A	N/A	4.57E+03	6.47E+01	N/A	N/A	1.40E+01
1,1-Dichloroethene	2.46E+03	N/A	N/A	1.78E+02	2.51E+00	N/A	N/A	5.43E-01
1,1-Dichloroethane	2.11E+07	N/A	N/A	1.52E+06	2.16E+04	N/A	N/A	4.65E+03
Vinyl Acetate	1.26E+06	N/A	N/A	9.14E+04	1.29E+03	N/A	N/A	2.79E+02
1,3-Dichloropropene	2.27E+04	N/A	N/A	1.64E+03	2.32E+01	N/A	N/A	5.01E+00
1,1,2-Trichloroethane	5.17E+04	N/A	N/A	3.74E+03	5.29E+01	N/A	N/A	1.14E+01
Bromoform	7.56E+05	N/A	N/A	5.74E+04	7.74E+02	N/A	N/A	1.67E+02
Tetrachloroethene	1.64E+06	N/A	N/A	1.19E+05	1.68E+03	N/A	N/A	3.62E+02
Chlorobenzene	1.05E+06	N/A	N/A	7.62E+04	1.08E+03	N/A	N/A	2.33E+02
Ethylbenzene	6.32E+06	N/A	N/A	4.57E+05	6.47E+03	N/A	N/A	1.40E+03
Styrene	1.47E+06	N/A	N/A	1.07E+05	1.51E+03	N/A	N/A	3.26E+07
Vinyl Chloride	1.02E+05	N/A	N/A	7.35E+03	1.04E+02	N/A	N/A	2.25E+01
1,2-Dichloroethane	3.24E+04	N/A	N/A	2.34E+03	3.32E+01	N/A	N/A	7.16E+00
1,2-Dichloropropane	2.27E+04	N/A	N/A	1.64E+03	2.32E+01	N/A	N/A	5.01E+00
1,1,2,2-Tetrachloroethane	1.47E+04	N/A	N/A	1.07E+03	1.51E+01	N/A	N/A	3.26E+00
2-Chloroethyl Ether	2.68E+03	N/A	N/A	1.94E+02	2.74E+00	N/A	N/A	5.92E-01
1,4-Dichlorobenzene	4.21E+06	N/A	N/A	3.05E+05	4.31E+03	N/A	N/A	9.30E+02
1,2-Dichlorobenzene	8.42E+06	N/A	N/A	6.09E+05	8.62E+03	N/A	N/A	1.86E+03
Nitrobenzene	1.26E+05	N/A	N/A	9.14E+03	1.29E+02	N/A	N/A	2.79E+01
Hexachloroethane	2.11E+05	N/A	N/A	1.52E+04	2.16E+02	N/A	N/A	4.65E+01
1,2,4-Trichlorobenzene	6.32E+05	N/A	N/A	4.57E+04	6.47E+02	N/A	N/A	1.40E+02
Hexachlorobutadiene	3.78E+04	N/A	N/A	2.73E+03	3.87E+01	N/A	N/A	8.35E+00
Hexachlorocyclopentadiene	4.21E+03	N/A	N/A	3.05E+02	4.31E+00	N/A	N/A	9.30E-01
2,4,6-Trichlorophenol	2.68E+05	N/A	N/A	1.94E+04	2.47E+02	N/A	N/A	5.92E+01
Hexachlorobenzene	1.84E+03	N/A	N/A	1.33E+02	1.89E+00	N/A	N/A	4.07E-01

NOTE: Threshold values exceeding 1E06 ug/g indicate that under the assumed site conditions (i.e., nature of activity, soil moisture, wind speed, etc.), the acceptable risk to an off-site receptor will never be exceeded. This is due to the fact that the concentration of a contaminant can never exceed 1E06 ug/g; thus, the soil threshold level will never be reached.

SOIL THRESHOLD LEVELS – ZONE C

PCs	ACTIVITY							
	DRILLING	VEHICLE TRAFFIC (LIGHT)	VEHICLE TRAFFIC (HEAVY)	MINOR EXCAVATIONS (TEST PIT)	REMOVAL BY SCRAPER	MAJOR EXCAVATIONS		
						UNLOADING BY SCRAPER	TRANS. BY SCRAPER	FRONT- SHOVL OPS
Radionuclides, pCi/g								
Uranium 233 & 234	2.01E+05	5.25E+03	5.25E+02	1.05E+08	1.25E+04	1.27E+06	5.90E+01	N/A
Uranium 235	2.17E+05	5.67E+03	5.67E+02	1.13E+08	1.35E+04	1.37E+06	6.38E+01	N/A
Uranium 238	2.26E+05	5.90E+03	5.90E+02	1.18E+08	1.41E+04	1.43E+06	6.64E+01	N/A
Americium 241	1.36E+05	3.54E+03	3.54E+02	7.07E+07	8.44E+03	8.59E+05	3.99E+01	N/A
Plutonium 239 & 240	1.33E+05	3.45E+03	3.45E+02	6.90E+07	8.23E+03	8.38E+05	3.89E+01	N/A
Tritium (gas)**	6.97E+10	1.82E+09	1.82E+08	3.63E+13	4.33E+09	4.41E+11	2.04E+07	N/A
Strontium 89	1.87E+09	4.88E+07	4.88E+06	9.76E+11	1.16E+08	1.19E+10	5.50E+05	N/A
Strontium 90	9.70E+07	2.53E+06	2.53E+05	5.05E+10	6.03E+06	6.14E+08	2.85E+04	N/A
Cesium 137	1.11E+08	2.89E+06	2.89E+05	5.78E+10	6.89E+06	7.01E+08	3.25E+04	N/A
Radium 226	1.81E+06	4.72E+04	4.72E+03	9.43E+08	1.13E+05	1.15E+07	5.31E+02	N/A
Radium 228	8.36E+06	2.18E+05	2.18E+04	4.35E+09	5.19E+05	5.29E+07	2.45E+03	N/A
Non-Radionuclides, ug/g								
Arsenic	1.94E+05	5.07E+03	5.07E+02	1.26E+07	6.04E+03	6.15E+05	1.15E+02	4.59E+04
Barium	6.94E+07	1.81E+06	1.81E+05	4.50E+09	2.16E+06	2.20E+08	4.09E+04	1.64E+07
Beryllium	1.16E+06	3.02E+04	3.02E+03	7.51E+07	3.59E+04	3.66E+06	6.82E+02	2.73E+05
Cadmium	1.59E+06	4.15E+04	4.15E+03	1.03E+08	4.95E+04	5.04E+06	9.39E+02	3.76E+05
Chromium III	3.96E+05	1.03E+04	1.03E+03	2.57E+07	1.23E+04	1.25E+06	2.33E+02	9.34E+04
Chromium VI	3.96E+05	1.03E+04	1.03E+03	2.57E+07	1.23E+04	1.25E+06	2.33E+02	9.34E+04
Manganese	7.91E+06	2.06E+05	2.06E+04	5.13E+08	2.46E+05	2.50E+07	4.66E+03	1.87E+06
Mercury	5.97E+06	1.56E+05	1.56E+04	3.87E+08	1.85E+05	1.89E+07	3.52E+03	1.41E+06
Hexachlorocyclohexane (alpha)	1.54E+06	4.02E+04	4.02E+03	1.00E+08	4.79E+04	4.88E+06	9.09E+02	3.64E+05
Hexachlorocyclohexane (beta)	5.40E+06	1.41E+05	1.41E+04	3.50E+08	1.68E+05	1.71E+07	3.18E+03	1.27E+06
Heptachlor	2.16E+06	5.63E+04	5.63E+03	1.40E+08	6.71E+04	6.83E+06	1.27E+03	5.10E+05
Heptachlor Epoxide	1.07E+06	2.78E+04	2.78E+03	6.93E+07	3.32E+04	3.38E+06	6.30E+02	2.52E+05
Aldrin	5.72E+05	1.49E+04	1.49E+03	3.71E+07	1.78E+04	1.81E+06	3.37E+02	1.35E+05
Dieldrin	6.07E+06	1.58E+05	1.58E+04	3.94E+08	1.89E+05	1.92E+07	3.58E+03	1.43E+06
DDT	2.86E+07	7.45E+05	7.45E+04	1.85E+09	8.88E+05	9.04E+07	1.68E+04	6.75E+06
Chlordane (alpha, gamma)	7.48E+06	1.95E+05	1.95E+04	4.85E+08	2.32E+05	2.36E+07	4.41E+03	1.76E+06
Toxaphene	8.84E+06	2.30E+05	2.30E+04	5.73E+08	2.74E+05	2.79E+07	5.21E+03	2.08E+06
VOCs & Semi-VOCs, ug/g								
Chloroform	7.08E+04	N/A	N/A	5.00E+03	7.08E+01	N/A	N/A	1.53E+01
1,1,1-Trichloroethane	1.23E+08	N/A	N/A	8.69E+06	1.23E+05	N/A	N/A	2.65E+04
Carbon Tetrachloride	4.41E+04	N/A	N/A	3.12E+03	4.41E+01	N/A	N/A	9.52E+00
Benzene	1.91E+05	N/A	N/A	1.35E+04	1.91E+02	N/A	N/A	4.13E+01
Toluene	2.46E+07	N/A	N/A	1.74E+06	2.46E+04	N/A	N/A	5.31E+03
Dichloromethane	2.87E+06	N/A	N/A	2.03E+05	2.87E+03	N/A	N/A	6.19E+02
Xylenes	3.68E+06	N/A	N/A	2.61E+05	3.69E+03	N/A	N/A	7.96E+02
MEK	3.68E+07	N/A	N/A	2.61E+06	3.69E+04	N/A	N/A	7.96E+03
1,2-Dichloroethane	6.30E+04	N/A	N/A	4.45E+03	6.30E+01	N/A	N/A	1.36E+01
Bromomethane	8.19E+05	N/A	N/A	5.79E+04	8.19E+02	N/A	N/A	1.77E+02
Carbon Disulfide	1.23E+05	N/A	N/A	8.69E+03	1.23E+02	N/A	N/A	2.65E+01
1,1-Dichloroethene	4.78E+03	N/A	N/A	3.38E+02	4.78E+00	N/A	N/A	1.03E+00
1,1-Dichloroethane	4.09E+07	N/A	N/A	2.90E+06	4.10E+04	N/A	N/A	8.84E+03
Vinyl Acetate	2.46E+06	N/A	N/A	1.74E+05	2.46E+03	N/A	N/A	5.31E+02
1,3-Dichloropropene	4.41E+04	N/A	N/A	3.12E+03	4.41E+01	N/A	N/A	9.52E+00
1,1,2-Trichloroethane	1.01E+05	N/A	N/A	7.11E+03	1.01E+02	N/A	N/A	2.17E+01
Bromoform	1.47E+06	N/A	N/A	1.04E+05	1.47E+03	N/A	N/A	3.17E+02
Tetrachloroethene	3.18E+06	N/A	N/A	2.25E+05	3.19E+03	N/A	N/A	6.88E+02
Chlorobenzene	2.05E+06	N/A	N/A	1.45E+05	2.05E+03	N/A	N/A	4.42E+02
Ethylbenzene	1.23E+07	N/A	N/A	8.69E+05	1.23E+04	N/A	N/A	2.65E+03
Styrene	2.87E+06	N/A	N/A	2.03E+05	2.87E+03	N/A	N/A	6.19E+02
Vinyl Chloride	1.98E+05	N/A	N/A	1.40E+04	1.98E+02	N/A	N/A	4.27E+01
1,2-Dichloroethane	6.30E+04	N/A	N/A	4.45E+03	6.30E+01	N/A	N/A	1.36E+01
1,2-Dichloropropane	4.41E+04	N/A	N/A	3.12E+03	4.41E+01	N/A	N/A	9.52E+00
1,1,2,2-Tetrachloroethane	2.87E+04	N/A	N/A	2.03E+03	2.87E+01	N/A	N/A	6.19E+00
2-Chloroethyl Ether	5.21E+03	N/A	N/A	3.68E+02	5.21E+00	N/A	N/A	1.13E+00
1,4-Dichlorobenzene	8.19E+06	N/A	N/A	5.79E+05	8.19E+03	N/A	N/A	1.77E+03
1,2-Dichlorobenzene	1.64E+07	N/A	N/A	1.16E+06	1.64E+04	N/A	N/A	3.54E+03
Nitrobenzene	2.46E+05	N/A	N/A	1.74E+04	2.46E+02	N/A	N/A	5.31E+01
Hexachloroethane	4.09E+05	N/A	N/A	2.90E+04	4.10E+02	N/A	N/A	8.84E+01
1,2,4-Trichlorobenzene	1.23E+06	N/A	N/A	8.69E+04	1.23E+03	N/A	N/A	2.65E+02
Hexachlorobutadiene	7.35E+04	N/A	N/A	5.20E+03	7.35E+01	N/A	N/A	1.59E+01
Hexachlorocyclopentadiene	8.19E+03	N/A	N/A	5.79E+02	8.19E+00	N/A	N/A	1.77E+00
2,4,6-Trichlorophenol	5.21E+05	N/A	N/A	3.68E+04	5.21E+02	N/A	N/A	1.13E+02
Hexachlorobenzene	3.58E+03	N/A	N/A	2.53E+02	3.58E+00	N/A	N/A	7.74E-01

NOTE: Threshold values exceeding 1E06 ug/g indicate that under the assumed site conditions (i.e., nature of activity, soil moisture, wind speed, etc.), the acceptable risk to an off-site receptor will never be exceeded. This is due to the fact that the concentration of a contaminant can never exceed 1E06 ug/g; thus, the soil threshold level will never be reached.

SOIL THRESHOLD LEVELS – OPERABLE UNIT 3

PCs	ACTIVITY							
	DRILLING	VEHICLE TRAFFIC (LIGHT)	VEHICLE TRAFFIC (HEAVY)	MINOR EXCAVATIONS (TEST PIT)	REMOVAL BY SCRAPER	MAJOR EXCAVATIONS UNLOADING BY SCRAPER	TRANS. BY SCRAPER	FRONT-SHOVEL OPS
Radionuclides, pCi/g								
Uranium 233 & 234	1.28E+04	3.39E+02	2.88E+01	N/A	N/A	N/A	N/A	N/A
Uranium 235	1.39E+04	3.66E+02	3.11E+01	N/A	N/A	N/A	N/A	N/A
Uranium 238	1.45E+04	3.81E+02	3.24E+01	N/A	N/A	N/A	N/A	N/A
Americium 241	8.67E+03	2.29E+02	1.95E+01	N/A	N/A	N/A	N/A	N/A
Plutonium 239 & 240	8.46E+03	2.23E+02	1.90E+01	N/A	N/A	N/A	N/A	N/A
Tritium (gas)**	4.45E+09	1.17E+08	9.98E+06	N/A	N/A	N/A	N/A	N/A
Strontium 89	1.20E+08	3.15E+06	2.68E+05	N/A	N/A	N/A	N/A	N/A
Strontium 90	6.19E+06	1.63E+05	1.39E+04	N/A	N/A	N/A	N/A	N/A
Cesium 137	7.08E+06	1.87E+05	1.59E+04	N/A	N/A	N/A	N/A	N/A
Radium 226	1.16E+05	3.05E+03	2.60E+02	N/A	N/A	N/A	N/A	N/A
Radium 228	5.34E+05	1.41E+04	1.20E+03	N/A	N/A	N/A	N/A	N/A
Non-Radionuclides, ug/g								
Arsenic	1.24E+04	3.27E+02	2.79E+01	N/A	N/A	N/A	N/A	N/A
Barium	4.43E+06	1.17E+05	9.95E+03	N/A	N/A	N/A	N/A	N/A
Beryllium	7.39E+04	1.95E+03	1.66E+02	N/A	N/A	N/A	N/A	N/A
Cadmium	1.02E+05	2.68E+03	2.28E+02	N/A	N/A	N/A	N/A	N/A
Chromium III	2.53E+04	6.66E+02	5.67E+01	N/A	N/A	N/A	N/A	N/A
Chromium VI	2.53E+04	6.66E+02	5.67E+01	N/A	N/A	N/A	N/A	N/A
Manganese	5.05E+05	1.33E+04	1.13E+03	N/A	N/A	N/A	N/A	N/A
Mercury	3.81E+05	1.01E+04	8.55E+02	N/A	N/A	N/A	N/A	N/A
Hexachlorocyclohexane (alpha)	9.85E+04	2.60E+03	2.21E+02	N/A	N/A	N/A	N/A	N/A
Hexachlorocyclohexane (beta)	3.45E+05	9.09E+03	7.74E+02	N/A	N/A	N/A	N/A	N/A
Heptachlor	1.38E+05	3.64E+03	3.09E+02	N/A	N/A	N/A	N/A	N/A
Heptachlor Epoxide	6.82E+04	1.80E+03	1.53E+02	N/A	N/A	N/A	N/A	N/A
Aldrin	3.65E+04	9.63E+02	8.19E+01	N/A	N/A	N/A	N/A	N/A
Dieldrin	3.88E+05	1.02E+04	8.70E+02	N/A	N/A	N/A	N/A	N/A
DDT	1.82E+06	4.81E+04	4.10E+03	N/A	N/A	N/A	N/A	N/A
Chlordane (alpha, gamma)	4.77E+05	1.26E+04	1.07E+03	N/A	N/A	N/A	N/A	N/A
Toxaphene	5.64E+05	1.49E+04	1.27E+03	N/A	N/A	N/A	N/A	N/A
VOCs & Semi-VOCs, ug/g								
Chloroform	4.52E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1,1-Trichloroethane	7.84E+06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Carbon Tetrachloride	2.81E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzene	1.22E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Toluene	1.57E+06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dichloromethane	1.83E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Xylenes	2.35E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MEK	2.35E+06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichloroethane	4.02E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bromomethane	5.23E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Carbon Disulfide	7.84E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1-Dichloroethene	3.05E+02	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1-Dichloroethane	2.61E+06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vinyl Acetate	1.57E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,3-Dichloropropene	2.81E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1,2-Trichloroethane	2.81E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bromoform	9.38E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene	2.03E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chlorobenzene	1.31E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ethylbenzene	7.84E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Styrene	1.83E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vinyl Chloride	1.26E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichloroethane	4.02E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichloropropane	2.81E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,1,2,2-Tetrachloroethane	1.83E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Chloroethyl Ether	3.33E+02	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,4-Dichlorobenzene	5.23E+05	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2-Dichlorobenzene	1.05E+06	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrobenzene	1.57E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hexachloroethane	2.61E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1,2,4-Trichlorobenzene	7.84E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hexachlorobutadiene	4.69E+03	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hexachlorocyclopentadiene	5.23E+02	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2,4,6-Trichlorophenol	3.33E+04	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hexachlorobenzene	2.29E+02	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: Threshold values exceeding 1E06 ug/g indicate that under the assumed site conditions (i.e., nature of activity, soil moisture, wind speed, etc.), the acceptable risk to an off-site receptor will never be exceeded. This is due to the fact that the concentration of a contaminant can never exceed 1E06 ug/g; thus, the soil threshold level will never be reached.

APPENDIX 6

DISPERSION PREVENTION TECHNIQUES

A.6.1 INTRODUCTION

This appendix discusses the measures that can be used to control the dust and vapors which may be produced during remedial investigations in work areas classified as Stage 2 at RFP. The measures will be summarized here since they have been described in detail in various EPA publications, particularly the Dust Control Handbook (EPA 1985). A two step process was used to identify control measures. First, the control measures which are commonly used (or logically could be used) for the activities involved in a remedial investigation were evaluated by reviewing the literature and interviewing RFP personnel. During this process, unproven technologies and control technologies incompatible with the operations being performed were eliminated from consideration. For example, use of a protective enclosure for a roadway and use of vacuum truck to decontaminate topsoil were ruled out. The second step of the process was to evaluate or rank the control measures which are technologically feasible for each dust or vapor producing activity, e.g., excavation, well drilling, etc.

The methods of control were first ranked in terms of effectiveness and their implementability. Each measure was scored on a scale of 0-4, with 4 being the highest, for each of the two attributes. Cost considerations were only applied as a tie-breaker. This screening process parallels EPA RI/FS guidance (Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA 1988, OSWER Directive 9355.3-01). The scoring system is shown in Table A.6-1. Quantitative data were used as the basis of the rating, when they were available. However, for implementability and where quantitative data were not available, a reasonable judgement and/or qualitative descriptions from other studies were used. The scores for effectiveness and implementability for each control measure were added, with equal weight given to each, to determine the preferred method of control. A score of zero in any category eliminated the control from consideration for the activity being investigated.

TABLE A.6-1
SCORING SYSTEM FOR RATING CONTROL MEASURES

SCORE	EFFECTIVENESS	IMPLEMENTABILITY
4	Highly effective	Easily implemented
3	Very effective	Implementable with some difficulty
2	Less effective	Implementable with major difficulty
1	Not very effective	Implementable only with extreme difficulty
0	Ineffective or not suited to application	Impossible to implement for this application

A.6.2 GENERAL CONTROL MEASURES

There are a number of good operational practices which should be implemented for dust control at Stage 2 contaminated sites. These principles should be adhered to whenever possible and therefore are not considered below as alternatives. The following list of practices follow the Construction Dust Suppression Feasibility Study (Engineering-Science 1990) with some additions. These operational practices will be implemented to the extent practicable on any Stage 2 activity at RFP by the Project Manager.

- Minimize the number of times contaminated soil is moved or disturbed.
- Minimize the land surface area which is disturbed or cleared.
- Proceed expeditiously once work is initiated.
- Protect the vegetative cover outside the construction area and restore vegetation in the area upon completion of construction activities.

- Minimize vehicle and equipment movement in the construction zone.
- Wheeled vehicles are preferred over tracked vehicles for dust minimization.
- Low profile activities, such as pushing or grading, are preferred over batch drop or dumping operations.
- Minimize mud and dirt carryout from construction sites to paved roads as a matter of good housekeeping. For example, muddy areas should be regraded or graveled.
- Limit vehicle traffic on unpaved roads.
- Speed on unpaved roads should be controlled.

A.6.3 DUST PRODUCING ACTIVITIES DURING REMEDIAL INVESTIGATIONS

Several dust producing activities are expected to occur at RFP during remedial investigation activities.

A.6.3.1 Major Excavations

These are large construction projects in which various types of earthmoving equipment are used and multiple operations are necessary to accomplish the excavation. An example is the french drain installation for the 881 Hillside Phase II-B Interim Remedial Action Project which will involve the following dust producing activities (Engineering-Science 1990):

- The top twelve inches of soil in the french drain trench area will be removed for temporary storage in a low covered pile.
- The topsoil from the influent collection trench associated with the french drain will be removed and placed in a low covered pile.

- The balance (below topsoil) of the french drain trench and the influent collection trench will then be dug and only conventional dust control measures implemented.

A.6.3.2 Minor Excavations

These are typically short-term (1-3 day) projects in which only relatively small amounts of dirt are moved in a limited area. The prime example of this type of excavation is the test pit. Test pits are prepared by removing the first six inches of soil with a backhoe. This soil, which could be contaminated, is then stored in a covered pile. A pit 7 feet long, 5 feet wide, and 4 feet deep is then excavated by the backhoe. This operation is a material drop with no transportation of contaminated material, and it should be completed in one day, resulting in only a few trips by vehicles over potentially contaminated areas.

A.6.3.3 Drilling

This activity consists of drilling test wells or monitoring wells in potentially contaminated areas, using a hollow-stem auger technique. The auger is removed and core samples are normally taken at six foot intervals. Once the drilling equipment is in place, only light vehicle traffic will cross contaminated areas. Contaminated drill cuttings may be placed in drums for disposal.

A.6.3.4 Unpaved Roadways

Traffic over potentially contaminated roadways is expected to increase during remediation activities . The traffic may be either characterized as heavy or light in frequency. Light vehicular traffic is associated with minor excavations.

A.6.4 DUST CONTROL MEASURES

The following section discusses various control measures for the dust producing activities and indicates how the measures were selected. The measures considered for each activity are summarized in Table A.6-2.

A.6.4.1 Major Excavations (Interim Remedial Actions)

The dust control methods rated for their effectiveness and implementability for major excavations were: area spray with water, area spray with a water-surfactant mixture, chemical dust suppressants (including foam), spray curtain, windscreen, and containment structures. The emissions from heavy vehicle traffic are covered in a separate section for unpaved roads. The emission sources considered in this section are digging and material drop.

(1) **Area Spraying with Water.** This method involves wetting the area prior to excavation and wetting frequently as new soil is exposed. A study done in 1984 showed efficiencies for area spraying in the range of 62-70 percent for fine particulates during either traveling and scraping or dumping operations (EPA 1985).

TABLE A.6-2
PREVENTIVE MEASURES CONSIDERED FOR VARIOUS ACTIVITIES

Preventive Measures	Major Excavations (IRAs)	Minor Excavations (Test Pits)	Drilling	Unpaved Roads
Area Spraying with Water	X	X	X	X
Area Spraying with Water/ Surfactant	X	X	X	X
Chemical Dust Suppressants	X	X	X	X
Spray Curtains	X	X	Not Applicable	Not Applicable
Windscreens	X	X	X	Not Applicable
Containment Structure	X	X	Not Applicable	Not Applicable
Paving	Not Applicable	Not Applicable	Not Applicable	X

Therefore, area spraying with water was rated "very effective." Since this measure is commonly employed at construction sites and wetting can be performed with readily available equipment (water truck) and materials, a rating of "easily implemented" was assigned. In the recently completed 881 Hillside construction project, area spraying was successfully employed as a dust control measure. The total for this control method was 7 points.

(2) **Area Spraying with a Water-Surfactant Mixture.** Surfactants, such as soaps, detergents, and various commercial products, reduce the surface tension of water and allow better penetration. Theoretically the use of water with a surfactant

should increase the efficiency of the treatment over water alone; but, since the primary purpose of the surfactant is to reduce water consumption, both treatments are considered to be "very effective." Wetting can be performed with the same available equipment as with water spraying. However, there is a potential for workers to be exposed to concentrated chemicals for which there is evidence of adverse effects in animals (EPA 1985). In addition, these may be occasions where the surfactant could contaminate the soil and compromise the validity of analytical results and/or enhance contaminant mobility in soils. Therefore, a rating of "implementable with some difficulty" was assigned. The total for this treatment was 6 points.

(3) Chemical Dust Suppressants. Except for use in conjunction with a spray curtain (see below) or as a treatment for the work area (see A.6.4.4, Unpaved Roads), chemicals were not considered to be appropriate for use during digging operations because the area treated is continuously disturbed, greatly reducing their effectiveness. In addition, some of the drawbacks expressed in the use of surfactants apply here as well. Since a rating of "not suited to application" was assigned, chemicals were not rated for their implementability for this application.

(4) Spray Curtains. A spray curtain consists of a series of nozzles which produce a "flat" spray around a dump location (usually a truck). The liquid from the nozzles captures and moistens the particulates as they fall through the curtain. Since the potentially contaminated topsoil will probably be transported to temporary storage piles or the burial trenches by scrapers, this control could not be implemented for the initial phase of construction. Trucks will transport soil during excavation of the trenches and spray curtains were considered for this phase. In the same study cited above for area spraying (EPA 1985), results were reported for the effectiveness of both a water/surfactant spray and a chemical foam curtain. The water/surfactant spray was slightly more efficient than the chemical foam (56 versus 41 percent for fine particulates). However, neither method was as efficient as area

spraying. Based on these results spray curtains were rated as "less effective." This application would also be slightly more difficult to implement than area spraying since a spray curtain would have to be purchased or fabricated. Therefore it was rated as "implementable with some difficulty." The spray curtain was given a value of 5 points.

(5) Windscreens. Windscreens were studied as an alternative means of dust control for the Hillside 881 Project in Engineering-Science's Study (1990). Due to the size of the construction zone, a design incorporating two screens 160 feet long by 21 feet high and two screens 120 feet long by 21 feet high were considered. The study noted that rough terrain in the 881 hillside area could reduce the effectiveness of the windscreens by creating turbulent air flow and it suggested that windscreens be supplemented with other control means. Data on the effectiveness of windscreens are mixed. Some studies (EPA 1985) noted a reduction in total suspended particulates and inhalable particulates by 75 percent and 60 percent, respectively. However, another study indicated that windscreens did not reduce concentrations in the less than 10 micrometer respirable-size range. It was concluded that windscreens would probably be effective in reducing wind erosion of large particulates from disturbed areas and storage piles, but may not be effective in reducing off-site concentrations. Therefore, windscreens were rated as "not very effective." No adverse health effects for workers, other than the normal hazards of construction, are anticipated for the use of windscreens. However, the design studied in Engineering-Science (1990) also required 38 relocation operations, which will generate additional dust. This application was rated "implementable with major difficulty." The windscreen rating was 3 points.

(6) Containment Structure (tent). A ribbed fabric structure was selected for analysis by Engineering-Science (1990) for the 881 Hillside Project. Since the influent collection trench is wider than the largest standard size, a custom design was necessary. Because of the potentially windy conditions, it was assumed that the

structure would be placed on concrete pilings placed on 15 foot centers. Due to the uneven terrain, each relocation of the structure along the trench would require a custom installation, with a new set of pilings of differing lengths and additional materials to ensure a good seal with the ground. No figures were presented for control efficiency in the study. It is doubtful that 100 percent efficiency could be achieved, particularly in a structure to be built over a trench. Even if the efficiency of the structure itself is high, the additional dust generated during the construction of the pilings for numerous relocations and the relocation activities themselves offset its effectiveness. For these reasons, the containment structure was rated as "very effective" rather than "highly effective." Worker safety is a major concern in implementing this control because contaminants from the soil and pollutants from vehicle exhausts will be confined by the structure. Class C worker protection was assumed for cost analysis purposes in the study, resulting in decreased worker efficiency, heat stress, and lost productive time. In addition, upon completion of activities, the structure will probably have to be disposed of as a hazardous waste. As a result the use of a containment structure was rated as "implementable only with extreme difficulty." The total score was 4 points.

A.6.4.2 Minor Excavations (test pits)

The methods which were rated for their effectiveness and implementability for minor excavations were: area spray with water, area spray with a water-surfactant mixture, chemical dust suppressants (including foam), spray curtain, windscreen, and containment structure. The emission sources considered in this section are digging and material drop.

(1) **Area Spraying with Water.** This method is employed in the same manner as discussed for major excavations and is expected to be "very effective" and "easily implemented". This method was successfully implemented in the 881 Hillside

construction project, as discussed in the previous section. The total for this control method was 7 points.

(2) **Area Spraying with a Water-Surfactant Mixture.** The surfactant may interfere with the chemical analysis of results from the test pit. For this reason, a rating of "not suited to application" was assigned, and surfactants were not rated for their implementability for this application.

(3) **Chemical Dust Suppressants.** Chemicals also may interfere with the broad range of chemical analyses associated with the test pits. In addition, chemicals are not considered to be appropriate for use during digging operations because the treated area is continuously disturbed, greatly reducing their effectiveness. Since a rating of "not suited to application" was assigned, chemicals were not rated for their implementability or efficiency for this application.

(4) **Spray Curtain.** Spray curtains have found application in the loading of trucks but not during excavation (see discussion of spray curtains for major excavations, above). Since test pits will be constructed by a backhoe placing the excavated soil near the pit for later reuse, a rating of "not suited to application" was assigned and spray curtains were not rated for their implementability or efficiency for this application.

(5) **Windscreens.** As discussed in conjunction with major excavations, data on the effectiveness of windscreens are mixed (EPA 1985). Since they may not be effective in reducing off-site concentrations, windscreens were rated as "not very effective." In order to study the implementability and efficiency of this control for test pits, a windscreen was designed to protect the pit itself and separate piles of contaminated topsoil and clean soil. Additional length was added to account for up to a 45 degree change in wind direction. The result was a windscreen 8 feet high by

44 feet long. This application was rated "easily implemented." The total score for this method was 5 points.

(6) **Containment Structure.** In order to study this alternative for test pit construction, the minimum size of ribbed fabric structure to contain a backhoe, the test pit, and the temporary storage piles was computed to be a structure 30 feet by 40 feet by 15 feet high. No figures for control efficiency are available for this alternative, but, as discussed above, it is doubtful that 100 percent efficiency could be achieved. Even if the efficiency of the structure itself is high, the additional dust generated during the construction of the structure and numerous relocations reduce its effectiveness. For these reasons, the containment structure was rated as "very effective" rather than "highly effective." Worker safety and hazardous waste disposal considerations result in a rating of "implementable only with extreme difficulty." The selected structure could be moved on wheels in special channels to increase the efficiency of relocations or, if more than one test pit is active at a given time, additional structures would be constructed. In either case, the containment structure was rated as having significant implementability considerations. The total score was 4 points.

A.6.4.3 Drilling

The preventive measures considered for drilling activities were area spraying with water, area spraying with water mixed with a surfactant, chemical dust suppressants (including foam), and windscreens. Containment structures were not considered for a variety of reasons, including the low emissions from drilling, the confined area of activity, the height of the drill rig, and the higher moisture content of subsurface soil. The emissions from light vehicle traffic are covered in a separate section for unpaved roads. The emission sources considered in this section include drilling and auger removal.

(1) Area Spraying with Water. The emissions from drilling will occur in a limited area in the vicinity of the bore hole over a short period (one day or less). This area could be sprayed by a hand-held device, or an array of spray nozzles could be fabricated. This treatment, used successfully in the past, is expected to be "very effective" and "easily implemented". The total for this control method was 7 points.

(2) Area Spraying with a Water-Surfactant Mixture. Surfactants may interfere with the analysis of results from drilling. For this reason, use of a surfactant was scored as "not suited to application" and surfactants were not rated for their implementability for this application.

(3) Chemical Dust Suppressants. Chemicals may also interfere with the analysis of results from drilling. Since a rating of "not suited to application" was assigned, chemicals were not rated for their implementability or efficiency for this application.

(4) Windscreens. Since they may not be effective in reducing off-site concentrations, windscreens were rated as "not very effective." In order to study the implementability of this control, the same design postulated for test pits was assumed. This application was also rated "easily implemented" for drilling. The total score for this method was 5 points.

A.6.4.4 Unpaved Roads

The dust control methods of choice are spraying with water, spraying with water mixed with a surfactant, chemical dust suppressants, and paving (EPA 1985). Although it is not commonly thought of as a dust control measure itself, proper roadway preparation enhances the above measures by ensuring that good compaction can be achieved. Sampling to determine if the aggregates are present in the proper sizes and proportions to give good compaction should be undertaken prior to using

any unpaved, potentially contaminated road for heavy vehicle traffic. If the proper aggregate sizes and proportions are not present, the missing sizes can be added or a chemical dust suppressant can be chosen which will provide optimum control for the roadway conditions. The value of each of the control measures for unpaved roads is discussed below.

(1) Spraying with Water. Watering once per hour has an effectiveness of 50 percent. Watering twice as often will raise the effectiveness to 75 percent; and effectiveness near 100 percent has been obtained with applications of 0.125 gallons/square yard every 20 minutes (EPA 1985). The application rate must be set so that contaminated water runoff is not a problem. The use of water was rated "very effective." The equipment needed to apply this treatment, a water truck or calibrated spray bar, and equipment operators are readily available. However, the frequency of application is significantly higher than for chemicals which may only need to be applied every few weeks. Therefore, this treatment was scored "implementable with some difficulty". The total score for this application was 6 points.

(2) Spraying with Water Mixed with a Surfactant. The addition of the surfactant merely increases the penetration of the water into the roadbed. With the same level of watering, the use of a surfactant should increase the effectiveness of the treatment. Since surfactants are normally added to reduce water consumption, the effectiveness is considered to be the same (EPA 1985). The use of water with a surfactant was rated "very effective." The equipment used to apply this treatment is the same as for water-only treatment, and similar application frequency requirements apply. The exposure to certain concentrated surfactants prior to dilution is a concern for workers' safety, but no major environmental effects were noted (EPA 1985). Therefore, the treatment was rated "implementable with some difficulty." The total score for this application was 6 points.

(3) Chemical Dust Suppressants. In addition to surfactants used in conjunction with watering, there are three categories of products based on their method of dust control and chemical similarity: salts, adhesives, and bitumens. These products may be applied topically to the road surface or mixed in with the top layer of aggregate. A survey of the products available in 1983 showed that the effectiveness varied widely with the number of days since the last application, the application rate, traffic volume, vehicle size, the receiving surface, and testing methodologies. Efficiencies of 80 percent or greater were achieved within the first week after the initial application. Subsequent applications should be more effective, but no data was available (EPA 1985). Thus, chemical dust suppressants as a class were rated "very effective." A spray bar is preferred over a water truck for application of liquid chemicals to ensure the correct application rate, and mixing chemicals with the top layer of soil is more difficult than topical applications. In general, the chemicals used for dust suppression are neither toxic nor mobile in the environment (EPA 1985); however, this application may require worker protection. The introduction of additional persistent chemicals into the environment may cause other regulatory considerations at RFP. Because of these factors, the use of chemical dust suppressants was rated "implementable with major difficulty." The wide variety of chemicals available, each with a different application rate and long term effectiveness, makes a comparison with other dust reduction methods difficult. The total score for chemicals was 5 points.

(4) Paving. The Handbook of Dust Control (EPA 1985) notes a reduction of 98.5 percent in the base emission factor for paved versus unpaved roads. Paving was rated "highly effective" in reducing dust from roads. However, since multiple sites would each require temporary roads during remedial investigations, this solution was rated "implementable with extreme difficulty." Compared to other dust control measures this option was rated as having significant labor requirements. The total score for paving was 5 points.

A.6.5 CONCLUSIONS AND RECOMMENDATIONS

The ranking of preventive measures by activity are shown in Table A.6-3. If, based on the proposed activity, contaminant concentrations in the work area are such that a Stage 2 area is declared, the Project Manager will select and justify the choice of preventive measures that will be applied, starting with the highest ranking option. The results indicate that area spraying with water should be employed when soil activity levels are above the threshold. Monitoring, in accordance with Appendix 7 guidance, must be used to verify the effectiveness of the treatment. If an adequate water supply is available, water alone should be as effective as a water-surfactant mixture. The use of chemical dust suppressants is only recommended for unpaved roads with dust produced by heavy traffic which cannot be controlled by watering. Descriptions of chemical dust suppressants are included in Table A.6-4. For the major excavations, if the source of emissions appears to be truck loading operations, watering with a spray curtain should also be considered. If monitoring results indicate that watering alone is insufficient, then some means of reducing the wind speed in the vicinity of the dust-producing activity should be considered for digging or drilling operations. Paving is an option in the case of unpaved roads.

TABLE A.6-3
POINT RANKING AND APPLICATION OF PREVENTIVE MEASURES
FOR VARIOUS ACTIVITIES UNDER STAGE 2

Preventive Measures	Major Excavations (881 Hillside)	Minor Excavations (Test Pits)	Drilling	Unpaved Roads
Area Spraying with Water	7	7	7	6
Area Spraying with Water/ Surfactant	6	Not Rated	Not Rated	6
Chemical Dust Suppressants	Not Rated	Not Rated	Not Rated	5
Spray Curtains	5	Not Rated	Not Applicable	Not Applicable
Windscreens	3	5	5	Not Applicable
Containment Structure	4	4	Not Applicable	Not Applicable
Paving	Not Applicable	Not Applicable	Not Applicable	5

USE OF THIS TABLE (STAGE 2 AREAS ONLY)

- Identify activity to be performed (or if unpaved roads are present in the work area).
- Select highest ranking preventive measure (or justify use of another measure).
- If monitoring results indicate that the preventive measure is not satisfactory, cease work activities and apply the next method.
- If none of the preventive measures reduce airborne contaminant concentrations to acceptable levels, study alternative methods not included in this plan.

TABLE A-6-4
DESCRIPTION OF CHEMICAL SUPPRESSANTS AND SURFACTANTS

PRODUCT	SUPPLIER	TYPE/COMPOSITION	METHOD OF APPLICATION	EFFECTIVENESS	COMMENTS
CohereX	Cobitco, Inc. Denver, CO	Emulsified Petroleum Resin	Water Truck	Revegetated hillsides and light traffic roads (1 to 3 years)	Resins are dust-binding portion, wetting solutions as carrying and penetrating agents. Used successfully at Eagle Mine for dust control on tailings pile during periods of non-construction.
Dustrol 350	O'Brien Ind. Cleveland, OH	Emulsified Petroelum Resin	Water Truck	Revegetated hillsides and light traffic roads (1 to 3 years)	Same product as CohereX
Marloc	Buckley Powder Englewood, CO	Hydrophillic Waterborne Copolymer Emulsion	Water Truck or Hydroseeder	Revegetated hillsides and light traffic roads (1 year)	Develops a "plastic-like" coating over the soil surface. Allows the exchange of air and moisture, tends to reduce moisture evaporation at soil surface and is resistant to freeze-thaw.
Road-oyl	Soil Stabilization Products Co., Inc. Merced, CA	High Bonding Emulsion derived from natural pine tar	Water Truck	Light to heavy traffic roads (? years)	Used for dust control on haul roads. Bonding strength comparable to normal asphalt products. Prevents water erosion from run-off.
Dus-Top	WRR Ind. Salt Lake City, UT	Magnesium Chloride (salt)	Water Truck with spray bar or pressurized distribution spreader	Light to heavy traffic roads (1 year)	Product absorbs moisture from air and holds it. Base material must have sufficient $\frac{3}{4}$ " minus aggregates and fines to ensure binding. Road base required preparation for 3-inch deep product penetration. Compaction afterward also recommended.

TABLE A-6-4
DESCRIPTION OF CHEMICAL SUPPRESSANTS AND SURFACTANTS

PRODUCT	SUPPLIER	TYPE/COMPOSITION	METHOD OF APPLICATION	EFFECTIVENESS	COMMENTS
Soil Seal	Soil Stabilization Products Co., Inc. Merced, CA	Latex Acrylic Co-Polymer Soil Stabilizer	Water Truck	Revegetated hillsides only (18 months or less)	Forms a crust by cohesive binding of surface particles. To be used in areas with no traffic. Prevents soil erosion and does not effect vegetation.
Soil Master WR	Earth Systems Internation, Inc. Colorado Springs, CO	Tripolycate base material formulation	Water Truck	Revegetated hillsides and light traffic roads (18 months or less)	Forms a crust by cohesive binding of soil particles. Crust thickness varies between $\frac{1}{4}$ to $\frac{1}{2}$ inch. Not generally considered an economic method of dust control where there is traffic.
Dustdown 70	RBI Denver, CO	Fumic Acid Material	Water Truck	Revegetation hillsides and light traffic roads	Used at Rocky Mountain Arsenal
Terra Tack			Water Truck with spray bar or hydromulch	Revegetated areas	Used by Mission Viejo

A.6.6 REFERENCES

EPA 1985. Handbook, Dust Control at Hazardous Waste Sites, EPA/540/2-85/003, November 1985, Environmental Protection Agency.

Engineering-Science, Inc., 1990. Construction Dust Suppression Feasibility Study, 881 Hillside Remedial Action, Rocky Flats Plant, Golden, Colorado.

APPENDIX 7

AIR MONITORING REQUIREMENTS

A.7.1 INTRODUCTION

Air sampling and monitoring will be performed in both Stage 1 and Stage 2 work areas. Stage 1 refers to cases where the concentrations of hazardous substances (chemical or radiological) in an operable unit (OU) have been determined to be less than the soil threshold levels listed in Appendix 5 of the PPCD. Stage 2 refers to those cases where concentrations exceed the soil threshold levels.

Air monitoring procedures in the vicinity of a work site within an OU will be implemented to provide assurance that off-site exposure concentrations are kept within the limits imposed by the risk analysis (Appendix 4). Both real-time and, for Stage 2 areas, cumulative (integrating) concentrations of contaminants in air will be measured. Appropriate air sampling and monitoring instruments will be selected depending on the types of contaminants that are present or suspected to be present at the site.

The instruments used for the purpose of monitoring off-site concentrations may be the same as those used to monitor worker exposures. Concentrations of contaminants will be highest near the work site and decrease with distance. Therefore, these instruments will be most effective when placed as close as possible to the work site. The measured on-site concentrations will be scaled to the anticipated off-site concentrations by using a dispersion factor which takes into account the distance to the RFP boundary. This will provide assurance that the public, as well as the workers, are being protected.

A.7.2 RESPONSIBILITIES

The following persons will be responsible for ensuring that the air monitoring program is implemented in accordance with the requirements presented in this appendix.

The Project Manager (PM) will determine whether the site is subject to Stage 1 requirements or the more stringent Stage 2 requirements. This decision will be made on the basis of measured or suspected soil contaminant levels relative to the respective soil threshold levels (Appendix 5). The PM will also select the dust suppression measures required to minimize the generation of dust from intrusive activities (Stage 1 - Appendix 8 or Stage 2 - Appendix 6). The PM will measure soil moisture levels and determine whether wetting is necessary. Based on the prevailing wind direction, the PM will select the appropriate downwind location from the work site for the air sampling and monitoring equipment. In addition, the PM will monitor the instruments used to measure concentrations of airborne contaminants. The PM has the authority to stop work if any action levels or alarm settings are exceeded. The PM is also responsible for reporting the monitoring results and ensuring that the instruments are operable and calibrated. Once air monitoring samples have been analyzed and reduced, they will be reported immediately to the PM. The PM is responsible for the interpretation of the air monitoring and sampling data obtained during the work. On the basis of these data, the PM will implement any additional dust suppression measures deemed necessary. The PM will also determine and resolve the cause of any measurements of airborne contaminant concentrations above action levels.

The Health and Safety Coordinator (HSC) will select the appropriate air sampling and monitoring equipment to be used at each site and determine the appropriate action levels or alarm settings requiring cessation of work activities. The HSC also ensures that radiological and industrial hygiene measurements are taken

in accordance with established procedures. The HSC is assigned to the site by the Industrial Hygiene Manager and reports to the Project Manager.

The Air Programs Representative (APR) will set up the anemometer and report wind conditions to the workers' supervisor, the HSC, and the PM as specified in the work procedures.

A.7.3 SELECTION OF AIR MONITORING AND SAMPLING EQUIPMENT

Applicability of monitoring and sampling equipment will be determined in part by the confirmed or suspected chemical and/or radiological contaminant(s) in the soil. The following equipment will be used to implement the air monitoring program:

- Anemometers to measure wind speed and direction
- Instruments to measure soil moisture
- Real-time contaminant monitors
- High-volume air samplers

Anemometers will be capable of measuring the average wind speed and direction over 15 minute intervals. If not so equipped, the PM will take frequent readings and compute the 15 minute averages manually.

Soil moisture instruments will be capable of measuring moisture levels at or below the soil moisture threshold (as practicable) for the work activity.

Real-time contaminant monitors will provide assurance that airborne contaminants do not exceed predetermined concentration levels over short periods (i.e., 15 minute averages). They will be under the observation of a field technician. Work will be suspended by the PM if the technician observes a reading above the

predetermined limit. These monitors may be capable of measuring contaminant concentrations directly, but will most likely be capable only of indirectly measuring the concentrations (i.e, dust concentrations or organic vapor concentrations).

High-volume air samplers (Hi-Vols) are integrating devices that will provide long-term average concentrations for Stage 2 work areas. Hi-Vols, in conjunction with appropriate analytical protocols can be used to identify and quantify specific contaminants. Real-time TSP measurements will be the primary means of evaluating mitigative measures effectiveness. Sample analysis results will be used to confirm that contaminant concentrations were maintained below the predetermined limits for the duration of the work activities. The required sampling frequency and analysis turnaround time will be determined by the PM, based on the soil contamination levels and instrument sensitivity.

The following is a list of monitoring and sampling equipment that may be selected and each instrument's applicability.

Monitoring Equipment:

The TSI Piezobalance, Model 3500, is used to monitor respirable aerosols. The Piezobalance measures the mass concentration of aerosols in the 0.01 to 10 micrometer range. It requires two minutes for a measurement and displays the reading directly in milligrams per cubic meter (mg/m^3). The Piezobalance (or equivalent) will be used extensively to provide real-time monitoring of total suspended particulate (TSP).

A vacuum pump draws aerosol into the instrument at a rate of one liter per minute (L/min). Particles greater than 3.5 micrometers pass through an impactor to a precipitator. The smaller particles are then charged and deposited on a sensor - a quartz crystal that oscillates at its natural frequency. The oscillating frequency of

the sensor decreases by an amount that is proportional to the mass of particles deposited. The frequency change is detected periodically by a counter and the reading is displayed. After measurement is completed, the frequency change is converted to units of concentration, mg/m^3 , and displayed.

High-Volume Samplers:

Total suspended particulates in sizes up to 50 micrometers (μm) can be measured using high volume samplers. The high volume sampler draws ambient air into a covered housing and through a filter, and the total suspended particulates collect on the filter surface. The mass is computed by measuring both the mass of the TSP collected and the volume of air sampled.

Model 217 - Laser Particle Counter:

The particle counter measures two particle sizes simultaneously on two different channels. The range of particle size is 0.25 to 5.0 microns. Airborne particles are detected using a solid-state laser diode source and collection optics. Particles deflect light energy from the solid-state laser diode onto the collection optics. The collection optics focus the light on a photodiode that converts the bursts of light into electrical impulses. The pulse height is proportional to particle size. An audible alarm can be set to occur when the count exceeds a given limit. A printout shows the two selected particle sizes, the count for each size, count alarm limit, temperature, and relative humidity.

MINIRAMS:

The Miniature Real-Time Aerosol Monitor (MINIRAM) Model PDM-3 is a personal-size airborne particulate monitor. It uses a pulsed GaAlAs light-emitting source. The radiation scattered by airborne particles is sensed by a silicon-

photovoltaic detector. An optical interference-type filter screens out any light with a different wavelength than that of the pulsed source.

The MINIRAM measures the concentration of solid and liquid airborne particles from 0.1 to 10 micrometers in size. The concentration of aerosols is measured in units of milligrams per cubic meter (mg/cm^3).

The instrument is powered by a set of rechargeable Ni-Cd batteries that can provide continuous monitoring operation for over 8.5 hours, and it can retain stored information for approximately six months. An alarm system warns the user when the pre-set threshold concentration level has been exceeded.

The MINIRAM, which measures TSP in real-time, will be used (along with the Piezobalance) as a primary means of evaluating mitigative measures effectiveness.

HNU Trace Gas Analyzer

The HNU Trace Gas Analyzer is a portable photoionization detector that is used to measure the atmospheric concentration of trace gases. Molecules of gas absorb photons emitted by the instrument's ultraviolet (UV) light source and release electrons. The electrons travel to a collector electrode and create an electrical current which is measured and displayed as the corresponding concentration of gas in parts per million (ppm). The instrument's range of detection is 0.1 to 2000 ppm.

An audible alarm can be attached to the instrument to give an 85 decibel signal when a pre-set concentration is exceeded. A recorder can also be attached to the readout assembly to provide a hard copy of the data.

Photovac Microtip Hand Held Air Monitor

The Microtip measures the concentration of airborne ionizable gases in the range of 0.1 to 2000 ppm isobutylene equivalent. The sample inlet carries a gas stream to the ultraviolet (UV) light source. Photons generated by the UV source ionize specific molecules in the gas stream. The ionized molecules move to the collector electrode and generate a current proportional to the concentration of the gas. The instrument is equipped with an alarm which signals when the pre-set value is exceeded.

A.7.4 LOCATION OF AIR SAMPLING AND MONITORING EQUIPMENT

Monitoring instruments will be placed as close as possible to the work area (about 5 - 10 meters) without interfering with the work activities. The selected location must be far enough so as to not be in the wake of buildings or machinery. Instrument can be placed closest for activities such as drilling which do not involve frequent movement of machinery. It is recommended that instruments be placed as far as 10 meters away when the activities involve excavation and vehicular traffic. If the wind direction appears to change substantially, or if the work location moves, the instrument(s) will be repositioned accordingly. Since the exclusion zone for work in a contaminated area typically extends 30 feet from the work site, an appropriate downwind location will be inside, or along, the exclusion zone boundary.

Downwind real-time monitors and air samplers will be co-located to the extent possible. This will permit the PM to inspect several instruments simultaneously.

A.7.5 SELECTION OF ALARM SETTINGS OR ACTION LEVELS

Alarm settings or action levels will be established for soil moisture, wind speed, and airborne contaminant concentrations.

A.7.5.1 Soil Moisture

Soil moisture will be maintained above a minimum value as determined by the PM. Typically, this minimum will range from about 10 to 15 percent, depending on the soil type, vegetation, and any dust suppression measures that may have been implemented.

A.7.5.2 Wind Speed

Limits on average wind speed will be determined by the PM based on the type of dust-generating activities to be performed at the work site. Typically this limit will be set at 35 mph for drilling and small-scale excavation activities and 15 mph for other activities.

A.7.5.3 Airborne Contaminant Concentrations - Off-Site Exposures

Measuring concentrations of contaminants emitted from Stage 1 or 2 work areas directly at the RFP boundary is not practical. This is due mostly to the atmospheric dispersion that significantly reduces airborne concentrations from the point of origin. Consequently, air monitoring to evaluate the mitigative measures effectiveness will be implemented near the emission source. This requires establishing an action level concentration that can be measured near the emission source which is related to an acceptable concentration at the site boundary.

To estimate the concentration at the site boundary, a dispersion factor was derived for each of the four areas (OU3, A, B, C). These factors are listed in Table A.7-1 and account for the dilution that occurs from the work area (10 meters from the source) to the site boundary based on the prevailing atmospheric stability (Class D).

Table A.7-2 lists the limiting site boundary concentrations for the principal contaminants. These concentrations, derived from Appendix 5, represent the airborne levels associated with each compound's 1×10^{-6} lifetime excess cancer risk or 10% of the exposure dose/reference dose quotient. These concentrations limits are independent of the type of activity or area in which the activity is conducted. To obtain the equivalent on-site concentration (i.e., 10 meters away from the work area), these concentrations must be multiplied by the appropriate dispersion factor. In addition, if the instrument measures the contaminant carrier, a scaling factor must be applied. If dust is the contaminant carrier, this is accomplished by dividing the maximum on-site concentration of contaminant in air by the concentration of the contaminant in soil to obtain the limiting concentration of dust in air. This is repeated for each contaminant present in the soil. The action level is then set to the limiting (lowest) concentration of dust obtained by the above method.

When occupational limits for the contaminant exist, the action levels as calculated in the next section will usually be more restrictive than those calculated based on off-site protection criteria. This is due to the significant atmospheric dispersion factor (three to four orders of magnitude) that occurs between the work site and the site boundary. However, there are some contaminants for which no occupational limits have been established. In such cases, the off-site concentration limits will be the only applicable criteria in setting the action levels.

TABLE A.7-1

Dispersion Factors Used in Calculating Off-Site Action Levels

Zone	Distance to Receptor*	Dispersion Factor*
OU3	0.8 km	3,700
A	1.6 km	12,000
B	2.9 km	30,000
C	4.4 km	57,000

- * For Zone A, B, and C, this conservatively assumed to be the RFP site boundary.
- * Factor by which airborne contaminant concentration decreases: work area (10 meters from source) to RFP boundary.

Table A.7-2

SITE BOUNDARY LIMITING CONCENTRATIONS		
EPA Threshold Levels	L.E.C.R. Threshold Conc.	HI Threshold Conc.
Radionuclides	pCi/m3	
Uranium 233 & 234	4.2E-03	
Uranium 235	4.6E-03	
Uranium 238	4.8E-03	
Americium 241	2.9E-03	
Plutonium 239 & 240	2.8E-03	
Tritium (gas)**	1.5E+03	
Strontium 89	3.9E+01	
Strontium 90	2.0E+00	
Cesium 137	2.3E+00	
Radium 226	3.8E-02	
Radium 228	1.8E-01	
Non-Radionuclides	mg/m3	mg/m3
Arsenic	4.1E-06	
Barium		1.5E-03
Beryllium	2.4E-05	
Cadmium	3.3E-05	
Chromium III		8.3E-06
Chromium VI	5.0E-05	8.3E-06
Manganese		1.7E-04
Mercury		1.3E-04
Hexachlorocyclohexane (alpha)	3.2E-05	
Hexachlorocyclohexane (beta)	1.1E-04	
Heptachlor	4.5E-05	
Heptachlor Epoxide	2.2E-05	
Aldrin	1.2E-05	
Dieldrin	1.3E-04	
DDT	6.0E-04	
Chlordane (alpha, gamma)	1.6E-04	
Toxaphene	1.9E-04	
VOCs & Semi-VOCs	mg/m3	mg/m3
Chloroform	2.5E-03	
1,1,1-Trichloroethane		4.4E+00
Carbon Tetrachloride	1.6E-03	
Benzene	6.8E-03	
Toluene		8.8E-01
Dichloromethane	1.0E-01	1.3E+00
Xylenes		1.3E-01
MEK		1.3E+00
1,2-Dichloroethane	2.2E-03	
Bromomethane		2.9E-02
Carbon Disulfide		4.4E-03
1,1-Dichloroethene	1.7E-04	
1,1-Dichloroethane		1.5E+00
Vinyl Acetate		8.8E-02
1,3-Dichloropropene	1.6E-03	8.8E-03
1,1,2-Trichloroethane	3.6E-03	
Bromoform	5.2E-02	
Tetrachloroethene	1.1E-01	
Chlorobenzene		7.3E-02
Ethylbenzene		4.4E-01
Styrene	1.0E-01	
Vinyl Chloride	7.0E-03	
1,2-Dichloroethane	2.2E-03	
1,2-Dichloropropane	1.6E-03	
1,1,2,2-Tetrachloroethane	1.0E-03	
2-Chloroethyl Ether	1.9E-04	
1,4-Dichlorobenzene		2.9E-01
1,2-Dichlorobenzene		5.8E-01
Nitrobenzene		8.8E-03
Hexachloroethane	1.5E-02	
1,2,4-Trichlorobenzene		4.4E-02
Hexachlorobutadiene	2.6E-03	
Hexachlorocyclopentadiene		2.9E-04
2,4,6-Trichlorophenol	1.9E-02	
Hexachlorobenzene	1.3E-04	

An example derivation of an action level based on off-site concentration limits is given in Section 7.7 along with a comparison to the worker protection action level derived for the same contaminant.

A.7.5.4 Airborne Contaminant Concentrations - Occupational Exposures

Occupational exposure control is governed by the individual site specific health and safety plan. Details regarding the establishment of action levels and monitoring programs are detailed therein. The following discussion is provided to familiarize the reader with the method used at RFP for monitoring worker exposure to hazardous waste site contaminants. In general, to protect the workers, alarm settings or action levels will be calculated based on occupational concentration limits (DACs, TLV-TWAs, PELs, etc.). Concentration measurements are normally taken in the worker's breathing zone.

As mentioned above, the alarm settings and/or action levels for airborne emissions normally will be calculated at 10 percent of the occupational concentration limits when the instrument measures the contaminant directly. If the instrument measures a contaminant carrier (e.g., dust), the alarm will be set at a concentration equal to the ratio of the contaminant's limit in air (10% of DAC, PEL, TLV, etc.) to the measured or estimated concentration of the contaminant in soil.

If measured concentrations are between 10 and 100% of the DAC or TLV, appropriate respiratory equipment will be used or other measures taken to reduce worker exposures. Any concentrations measured above the occupational limits will result in a suspension of work activities and the application of mitigative measures.

Details of the Worker Protection Program are as follows:

An example derivation of an action level based on off-site concentration limits is given in Section 7.7 along with a comparison to the worker protection action level derived for the same contaminant.

A.7.5.4 Airborne Contaminant Concentrations - Occupational Exposures

Occupational exposure control is governed by the individual site specific health and safety plan. Details regarding the establishment of action levels and monitoring programs are detailed therein. The following discussion is provided to familiarize the reader with the method used at RFP for monitoring worker exposure to hazardous waste site contaminants. In general, to protect the workers, alarm settings or action levels will be calculated based on occupational concentration limits (DACs, TLV-TWAs, PELs, etc.). Concentration measurements are normally taken in the worker's breathing zone.

As mentioned above, the alarm settings and/or action levels for airborne emissions normally will be calculated at 10 percent of the occupational concentration limits when the instrument measures the contaminant directly. If the instrument measures a contaminant carrier (e.g., dust), the alarm will be set at a concentration equal to the ratio of the contaminant's limit in air (10% of DAC, PEL, TLV, etc.) to the measured or estimated concentration of the contaminant in soil.

If measured concentrations are between 10 and 100% of the DAC or TLV, appropriate respiratory equipment will be used or other measures taken to reduce worker exposures. Any concentrations measured above the occupational limits will result in a suspension of work activities and the application of mitigative measures. Details of the worker protection program will be contained in the site-specific health

An example derivation of an action level based on off-site concentration limits is given in Section 7.7 along with a comparison to the worker protection action level derived for the same contaminant.

A.7.5.4 Airborne Contaminant Concentrations - Occupational Exposures

Occupational exposure control is governed by the individual site specific health and safety plan. Details regarding the establishment of action levels and monitoring programs are detailed therein. The following discussion is provided to familiarize the reader with the method used at RFP for monitoring worker exposure to hazardous waste site contaminants. In general, to protect the workers, alarm settings or action levels will be calculated based on occupational concentration limits (DACs, TLV-TWAs, PELs, etc.). Concentration measurements are normally taken in the worker's breathing zone.

As mentioned above, the alarm settings and/or action levels for airborne emissions normally will be calculated at 10 percent of the occupational concentration limits when the instrument measures the contaminant directly. If the instrument measures a contaminant carrier (e.g., dust), the alarm will be set at a concentration equal to the ratio of the contaminant's limit in air (10% of DAC, PEL, TLV, etc.) to the measured or estimated concentration of the contaminant in soil.

If measured concentrations are between 10 and 100% of the DAC or TLV, appropriate respiratory equipment will be used or other measures taken to reduce worker exposures. Any concentrations measured above the occupational limits will result in a suspension of work activities and the application of mitigative measures. Details of the worker protection program will be contained in the site-specific health and safety plan.

The derived air concentrations are listed in Table A.7-3. Local Air Monitoring Trigger Levels for plutonium are listed in Appendix 8 (Attachment Two, Table 1.0). Occupational limits for non-radionuclides can be obtained from a current ACGIH TLV Book or the list of OSHA PELs.

TABLE A.7-3
Derived Air Concentrations

RADIONUCLIDE	DAC
PU-239	2 E-12 $\mu\text{Ci/ml}$
AM-241	2 E-12 $\mu\text{Ci/ml}$
U-238	2 E-11 $\mu\text{Ci/ml}$
U-235	2 E-11 $\mu\text{Ci/ml}$
U-234	2 E-11 $\mu\text{Ci/ml}$
CS-137	7 E-8 $\mu\text{Ci/ml}$
H-3	2 E-5 $\mu\text{Ci/ml}$

Note: The values for derived air concentrations (DAC) are based on either a stochastic dose limit of 5 rem or a nonstochastic dose limit of 50 rem per year, whichever is more limiting (DOE Order 5480.11)

A.7.6 WORK START/STOP CRITERIA

Work will not start or will be temporarily halted under any of the following circumstances:

- Soil moisture levels below the practicable threshold;
- Average wind speeds in excess of the threshold for two consecutive 15-minute periods;
- Real-time monitor alarm or readings above the occupational or off-site action level; or

- Air sample analysis showing concentration above the action level.

Under normal operating conditions (i.e., above the soil moisture threshold and below the wind speed threshold), no additional dust suppression methods should be required for Stage 1. Monitoring will be conducted to ensure compliance with occupational standards and to confirm that predicted rates are not exceeded. Since the 10m action levels are based on a back-calculation of dispersion to the site boundary, they are independent of the predicted emission rates. Airborne concentrations in excess of action levels or alarm settings will result in the suspension of activities until the cause is determined. This may require: a) repair of the monitor or sampler if found to be defective; b) changing the alarm settings and/or action levels if found to be miscalculated or too conservative; c) re-evaluating the dispersion/emission model; and/or d) re-analysis of the contaminant concentrations in soil. The conclusions obtained from such an assessment may require that the area be reclassified as a Stage 2 work area.

Stage 2 dust suppression measures (in addition to soil moisture and wind speed controls) will be taken prior to the start of operations to reduce the probability of exceeding the action levels. However, airborne contaminant concentrations in Stage 2 areas could increase above the action levels. Should monitors alarm and/or action levels be exceeded, additional dust suppression measures will be applied in accordance with the guidance presented in Appendix 6.

Work will start when the following conditions, where applicable, have been met:

- Minimum practicable soil moisture criterion is achieved;
- Average wind speeds are below the threshold for two consecutive 15-minute periods; and

- The cause for the monitor alarm or instrument readings above the action level has been determined and resolved.

A.7.7 EXAMPLE ACTION LEVEL CALCULATION

The following example is included to indicate how air monitoring action levels will be derived. This example assumes the drilling will occur in Zone A and that the principal contaminants are Pu-239 (1000 pCi/g) and beryllium (0.5 mg/g).

Based on the zone, activity, and contaminant concentrations, the PM would declare this a Stage 1 area since the soil threshold levels for drilling in Zone A are 28,000 pCi/g Pu-239 and 244 mg/g beryllium (see Appendix 5 for soil threshold levels).

The off-site action levels are calculated as follows. From Table A.7-1, the dispersion factor for work conducted in Zone A is 12,000. The off-site concentrations limits for Pu-239 and beryllium, obtained from Table A.7-2, are $2.8\text{E-}03$ pCi/m³ and $2.4\text{E-}05$ mg/m³, respectively. Note that these concentrations are two to three orders of magnitude lower than the comparable occupational limits. To obtain the equivalent on-site concentration limits (prior to dilution from work-site to the RFP boundary), the off-site limits are multiplied by the dispersion factor for Zone A. This results in concentration limits of 34 pCi/m³ and 0.29 mg/m³ for Pu-239 and beryllium, respectively, at 10 meters or less from the work site.

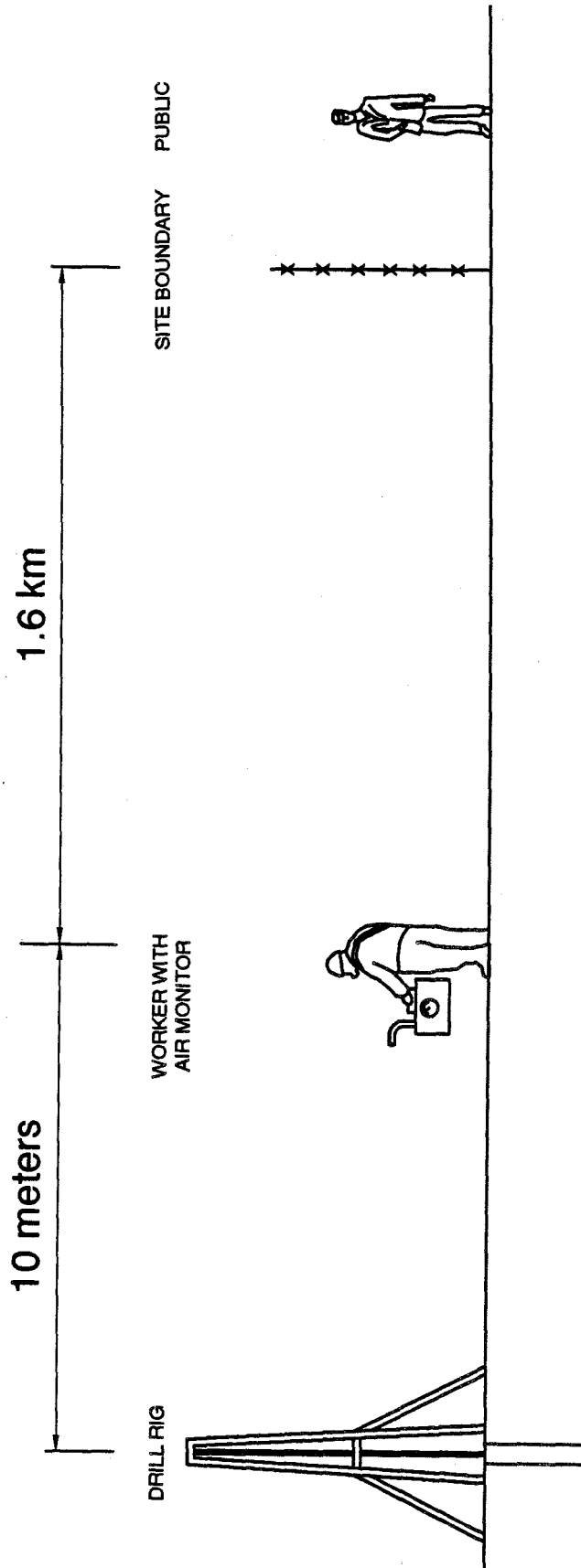
In this example, the off-site public is protected by an additional margin of safety when occupational limits are applied to the contaminants. To further expand on this point, the equivalent dust concentration action levels based on off-site concentration limits are 34 mg/m³ (based on 1000 pCi/g Pu-239 in soil) and 580 mg/m³ (based on 0.5 mg/g of beryllium in soil). The occupational (shut-down) action level of 2 mg/m³ (10 times the concentration listed in Table 1.0 of Attachment Two

to Appendix 8) is 17 times lower than the 34 mg/m³ off-site action level. This example is illustrated in Figure 7-1.

A.7.8 SUMMARY AND ACTION CHECKLIST

The following checklist is intended to summarize the requirements of the air sampling and monitoring plan to be applied to each work site. Note that these steps are to supplement the worker protection measures in the site-specific Health and Safety Plan.

- Determine the type of dust generating activities that will occur at the work site.
- Determine the area of the plant (OU3, A, B, or C, as defined in the PPCD) in which the activities will occur.
- Obtain measured (or estimate) concentrations of contaminants in the soil.
- Compare these concentrations to the most limiting soil threshold levels for the activity and plant area (listed in Appendix 5).
- If contaminant concentrations are below the soil threshold level, declare a Stage 1 work area; no additional dust suppression measures beyond maintaining minimum soil moisture levels will be required.
- If contaminant concentrations are above the soil threshold level, declare a Stage 2 work area; decide which dust suppression measures will be most effective based on location of work area and amount of contamination.
- Based on the contaminants present in the soil, select the monitoring and sampling equipment to measure airborne concentrations. For Stage 2 work areas, Hi-Vols are required. Determine the required sampling frequency and analysis turnaround times.



CONTAMINATED SOIL	OFF-SITE ACTION LEVEL:	ATMOSPHERIC DISPERSION FACTOR	10^{-6} LECR CONCENTRATION LIMIT:
1000 pCi/g	34 pCi/m^3 OR 34 mg/m^3 DUST	12,000	$2.8 \times 10^{-3} \text{ pCi/m}^3$ OR $2.8 \times 10^{-3} \text{ mg/m}^3$ CONTAMINATED DUST @ 1000 pCi/g

OCCUPATIONAL ACTION LEVELS:
 $0.2 \text{ mg/m}^3 \rightarrow$ USE RESPIRATORS
 $1.1 \text{ mg/m}^3 \rightarrow$ CEASE ACTIVITIES
CONSIDER ALTERNATIVES

FIGURE 7.1
EXAMPLE OF ACTION LEVEL
CALCULATION FOR AIR MONITORING

NOTE: Soil threshold for drilling in Zone A is 28,000 pCi/g, therefore, this is a stage 1 activity

- Based on the contaminant concentrations in soil and/or the airborne concentration limits (both occupational and off-site) and the instrument capabilities, set instrument alarm levels and determine action levels.
- Establish minimum soil moisture and maximum wind speed criteria.
- Verify that all monitoring and sampling instruments, including anemometer and soil moisture probes, are operable and calibrated.
- Measure soil moisture levels and, if necessary, wet the work area until the minimum soil moisture levels have been achieved.
- For work in a Stage 2 area, apply the selected dust suppression measures.
- Determine the prevailing wind direction and place the anemometer and the air monitoring and sampling equipment downwind and within 10 meters of the work area.
- Power the instruments and verify their proper operation.
- Begin work activities.
- Monitor the instruments periodically to ensure that all parameters are within established action levels.
- If the prevailing wind direction changes to the extent that the instruments are no longer downwind of the work site, or if the work site moves, relocate the instruments accordingly.
- Temporarily cease activities if average wind speeds exceed pre-established limits; resume activities when winds abate.
- Cease work activities if any of the concentration measurements exceed the action levels or alarm settings; analyze air sampling media; determine and resolve the cause of the excursion; and resume activities.
- Evaluate and report the results of routine air sampling analyses

A.7.9 REFERENCES

DOE Order 5480.11 December 21, 1988. Radiation Protection for Occupational Workers.

ATTACHMENT 7-1

AIR MONITORING CHECKLIST

The following checklist provides procedural guidance on implementing the air sampling and monitoring plan in the PPCD. Note that these steps are to supplement the worker protection measures in the site-specific Health and Safety Plan.

- ☐ List the type of dust generating activities that will occur at the work site (as defined in the PPCD).

Activity 1:

Activity 2:

Activity 3:

Activity 4:

- ☐ Enter the area of the plant (A, B, or C, or OU3 as defined in the PPCD) in which the activities will occur.

Area:

- ☐ Obtain measured (or conservatively estimate) concentrations of contaminants in the soil. Reference laboratory log number or write "Estimated".

Contaminant

Concentration (units)

Source

- ☐ Compare the concentrations entered above to the soil threshold levels (STL) for the activity and plant area (PPCD, Appendix 5).

<u>Contaminant</u>	<u>Concentration in Soil Measured/Estimated</u>	<u>S T L</u>
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- ☐ Are soil concentrations of all contaminants below the STLs?

Circle answer: YES NO

If answer is YES declare a Stage 1 work area (see Appendix 8 of PPCD for guidance). No additional dust suppression measures beyond maintaining minimum soil moisture levels will be required. Skip to the next step.

If answer is NO declare a Stage 2 work area. List dust suppression measures which will be most effective and/or implementable based on location of work area, activity to be performed and amount of contamination. Determine required air sampling frequency and analysis turnaround time. Justify your choice (see Appendix 6 of PPCD for dust suppression choices).

Dust suppression measure:

Justification:

Sampling frequency:

Analysis turnaround time:

Justification:

- ☐ Based on the contaminants present in the soil, circle the monitoring and sampling equipment that will be used to measure airborne concentrations (refer to Appendix 7). Verify that all instruments, including anemometer and soil moisture probes, are operable and calibrated.

Instrument

Anemometer
Piezobalance

Moisture Probe

Miniram

RadeCo High
Volume Sampler

HNU

OVA

Other:

- ☐ Based on the contaminant concentrations in soil and/or the airborne concentration limits and the instrument capabilities, set instrument alarm levels (if equipped) or determine action levels, both for occupational and off-site shutdown criteria (see Section 7.7, Appendix 7 of PPCD for an example). If contaminant is measured directly, enter action level for the contaminant. If measured indirectly, also enter action/alarm level for the contaminant carrier (e.g., maximum allowable dust concentration). This will be the ratio of action level to contaminant concentration in soil. If the instrument measures more than one contaminant, enter most restrictive action level.

<u>Instrument</u>	<u>Measured Parameter</u>	<u>Contaminant Action Level</u>	<u>Carrier Action Level (if applicable)</u>
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- ☐ From above list, circle the lowest action level if an instrument is used to monitor more than one contaminant or if both occupational and off-site concentration limits apply. Circle the category listed below which forms the basis for the action level:

OCCUPATIONAL LIMIT

OFF-SITE CONCENTRATION LIMIT

- ☐ Establish minimum soil moisture and maximum wind speed criteria.

Minimum soil moisture: %

Maximum wind speed: mph

- ☐ Measure soil moisture level and, if necessary, wet the work area until the minimum moisture level has been achieved.

Soil moisture: %

Wetting needed? YES NO

If YES, spray work area with water and repeat measurement. This activity should be conducted under the supervision of the project manager.

Final soil moisture: %

- ☐ For work in a Stage 2 area, apply the selected dust suppression measures.

- ☐ Determine the prevailing wind direction and place the anemometer and the air monitoring and sampling equipment downwind and within 10 meters of the work area.

Wind blowing from:

Wind speed: mph

Distance of instruments from work area: m

- ☐ Power the instruments and verify their proper operation.
- ☐ Begin work activities. Monitor the instruments periodically to ensure that all parameters are within established action levels.
- ☐ If the prevailing wind direction changes to the extent that the instruments are no longer downwind of the work site, or if the work site moves, relocate the instruments accordingly.
- ☐ Temporarily cease activities if average wind speeds exceed pre-established limits during two consecutive 15-minute intervals; resume activities when winds abate below limit for two consecutive 15-minute intervals.

- ☐ If any of the concentration measurements exceed the action levels or alarm settings:

CEASE ALL WORK ACTIVITIES

Analyze air sampling media

Determine and resolve the cause

After cause has been determined and resolved, obtain approval to resume activities

Document the occurrence, cause and resolution

- ☐ Evaluate and report the results of routine air sampling analyses.

APPENDIX 8

**INTERIM PLAN FOR PREVENTION
OF CONTAMINANT DISPERSION**

INTERIM-PLAN FOR PREVENTION OF CONTAMINANT DISPERSION

1) OBJECTIVE

The objective of this Interim-Plan for Prevention of Contaminant Dispersion (IPPCD) is to establish procedural requirements to mitigate potential hazards, on an interim basis, to persons located offsite as a result of contact with emissions resulting from intrusive remedial investigation activities.

2) SCOPE

Procedural requirements identified herein are applicable to certain intrusive actions taken at the 16 Operable Units (UOs) as part of the RFI/RI and IRA activities described in the Inter-Agency Agreement (IAG). Intrusive activities which fall within the scope of this IPPCD are those with the potential for producing appreciable quantities of suspended particulates (AQSP), primarily through mechanical actions. Intrusive activities potentially susceptible to producing AQSP include:

- o Monitoring well and soil/rock borehole installation.
- o Excavations such as trenching or test-pitting using powered equipment.

Additionally, heavy vehicular traffic associated intrusive RFI/RI activities shall be considered as susceptible to producing AQSP. By contrast, activities such as surface soil sampling with hand implements are not considered as susceptible to producing AQSP. Attachment One identifies activities for which Standard Operating Procedures (SOPs) exist that will likely require application of the requirements identified herein. Special consideration shall be given to Interim Remedial Action (IRA) construction-related activities that could require handling large quantities of soil.

Procedural requirements identified herein must be evaluated on a case-by-case basis to determine their potential impact on other IAG objectives. For example, it is possible that applying certain dispersion techniques, such as wetting, could compromise sample integrity and limit the usefulness of the data for which the sampling was intended.

The requirements identified in the IPPCD shall remain in effect until the final PPCD is approved or until modifications are approved and documented in the Site-Specific Health and Safety Plan (SSH&SP).

3) RESPONSIBILITY

The EG&G RFI/RI Project Manager (PM) shall be responsible for assuring that activities conducted at his/her OU are performed in accordance with the requirements identified herein, as well as other relevant procedures including the Environmental Monitoring and Assessment Division Standard Operating Procedures (i.e., the SOPs).

The Remediation Programs Division (RPD) Manager will be responsible for follow-up and auditing of the PM.

4) PROCEDURAL REQUIREMENTS

A pre-startup activity review to evaluate the potential for intrusive actions producing emissions of AQSP containing hazardous substances shall be conducted by the PM and the Activity Field Supervisor. If the activity is being performed by a subcontractor, the subcontractor's Activity Field Supervisor shall participate in the review.

The pre-startup activity review involving intrusive activities where there is significant potential for producing AQSP containing hazardous substances shall be documented by completion of a Radiological/H&S Work Permit (HSP 6.05) and an Excavation Permit (HSP 6.01). HSP's 6.05 and 6.01 are attached.

If the review establishes that there is significant potential for producing AQSP containing hazardous substances, the requirements identified below, as well as relevant SOPs, shall govern the activity.

4.1) SPECIFIC REQUIREMENTS

Activities where there is significant potential for producing AQSP containing hazardous substances shall not be conducted when the following conditions exist:

- o Sustained wind speeds above 15 miles per hour (mph) as measured by a site-located anemometer in the case of construction-related excavation, earth moving or other dust generating operations. Sustained winds above 15 mph exist when the 15-minute average wind

speed exceeds 15 mph for two consecutive 15-minute periods.

- o Sustained wind speeds above 35 miles per hour (mph) as measured by an anemometer located in the construction yard at the 881 Hillside in the case of drilling and related investigative activities.
- o When visible particulate matter emissions are observed originating from the intrusive activity.
- o Soils moisture content less than 15 percent (to the extent practicable) on roadways adjacent to the activity area as measured with a Soiltest "Speedy Moisture Tester" or equivalent instrument. Soils can be wetted to increase the moisture content to 15 percent if necessary.
- o When Total Suspended Particulate (TSP) concentrations measured in the vicinity of the activity exceed the site-specific trigger levels. Site-specific trigger levels are developed for key occupational contaminants of concern in each Site-Specific Health and Safety Plan. Table 1 and Figure 1 present typical site-specific trigger levels for ²³⁹Plutonium.

4.2) ADDITIONAL REQUIREMENTS

- o In the special case of excavations, the top 6" of soil will be moved (i.e., scraped) and placed in a low pile and covered with a tarp or other suitable covering to prevent resuspension of particulate.
- o In the case of construction-related materials containing potentially hazardous substances such as temporary piles from excavations, actions to prevent the emission of visible particulate matter will be applied as necessary. Such actions may include, but are not limited to, the application of dust suppressants and/or use of covers.

The potential for spreading contamination will be prevented through conscientious decontamination, material handling and monitoring practices. SOPs for these practices are identified as follows:

- o SOP 1.3; General Equipment Decontamination
- o SOP 1.4; Heavy Equipment Decontamination

- o SOP 1.5; Handling of Purge and Development Water
- o SOP 1.7; Handling of Decontamination Water and Wash Water
- o SOP 1.8; Handling of Drilling Fluids and Cuttings
- o SOP 1.9; Handling of Residual Samples
- o SOP 1.10; Receiving, Labeling and Handling of Waste Containers
- o SOP 1.12; Decontamination Facility Operations
- o SOP 1.13; Containerization, Preserving, Handling, and Shipping of Soil and Water Samples
- o SOP 1.15; Use of Photoionizing and Flame Ionizing Detectors
- o SOP 1.16; Field Radiological Measurements

4.3) AIR QUALITY MONITORING REQUIREMENTS

Air quality monitoring requirements for activities where there is a significant potential for producing appreciable quantities of suspended particulate include the following:

- o Site perimeter and community Radiological Ambient Air Monitoring Program (RAAMP).
- o Local monitoring of Total Suspended Particulate (TSP) at individual activity worksites shall be conducted using a TSI "Piezobalance" Model 3500 Aerosol Mass Monitor, real-time instrument (or equivalent). Local TSP measurements, in conjunction with site-specific trigger levels, will be used to guide the PM's evaluation of the potential hazards associated with activity related emissions.
- o In the special case of earth-moving activities related to Interim Remedial Action (IRA) construction, local TSP monitoring may be augmented with local high volume (Hi-Vol) air sampling. The determination to use Hi-Vol air sampling as well pertinent analysis, sampling duration, and quality control requirements, will be made at the pre-startup activity review.

- o Additional worker health and safety monitoring as required by the Site-Specific Health and Safety Plan.

Attachment Two provides additional information on these air monitoring requirements and identifies responsibilities for their implementation under the IPPCD.

Additional requirements that govern activities where there is a significant potential for producing appreciable quantities of suspended particulate include the following:

- o Excavated soils that are not promptly backfilled shall be covered with a tarp or similar cover to prevent resuspension of particulate.
- o Vehicular traffic will be minimized to the extent practicable.
- o Vehicular traffic shall not exceed 5 mph.
- o Roadways will be watered as necessary.

Restarting intrusive activities is the responsibility of the PM. Restart will be allowed when the condition that prompted cessation of intrusive activities has been alleviated. For example, if intrusive activities were halted because average wind speeds exceeding 15 miles per hour for two successive 15 minute periods were recorded, then restart can occur when an average of two successive 15 minute periods (i.e. 30 minutes) of less than 15 miles per hour is recorded. Another example is the cessation of intrusive activities resulting from the observation of visible particulate emissions originating from an activity such as vehicular traffic across an access path. In this case, the PM may resume traffic across the area of emissions after preventive actions (such as wetting) have resulted in the elimination of visible particulate emissions. Restart following shutdown as a result of exceeding the site-specific trigger level will not occur until consistent TSP measurements below the trigger level are observed.

Activity-specific requirements will be evaluated periodically to determine their effectiveness at preventing dispersion of contaminants from activities where there is a significant potential for producing appreciable quantities of suspended particulate. Modifications to these requirements will be documented in the Site-Specific Health and Safety Plan.

**ATTACHMENT ONE
STANDARD OPERATING PROCEDURES
TO CONSIDER FOR IMPLEMENTATION
OF THE IPPCD**

I SOPs for Activities Likely To Be Impacted By the IPPCD

- | | |
|---------|---|
| SOP 3.2 | Drilling and Sampling Using Hollow-Stem Auger Techniques |
| SOP 3.3 | Isolating Bedrock from Alluvium With Grouted Surface Casing |
| SOP 3.4 | Rotary Drilling and Rock Coring |

II SOPs That Affect IPPCD Activities

- | | |
|----------|--|
| SOP 1.1 | Title To Be Determined |
| SOP 1.3 | General Equipment Decontamination |
| SOP 1.4 | Heavy Equipment Decontamination |
| SOP 1.5 | Handling of Purge and Development Water |
| SOP 1.6 | Handling of Personal Protective Equipment |
| SOP 1.7 | Handling of Decontamination Water and Wash Water |
| SOP 1.8 | Handling of Drilling Fluids and Cuttings |
| SOP 1.9 | Handling of Residual Samples |
| SOP 1.10 | Receiving, Labeling and Handling of Waste Containers |
| SOP 1.12 | Decontamination Facility Operations |
| SOP 1.13 | Containerization, Preserving, Handling, and Shipping of Soil and Water Samples |
| SOP 1.15 | Use of Photoionizing and Flame Ionizing Detectors |
| SOP 1.16 | Field Radiological Measurements |

**ATTACHMENT TWO
IPPCD AIR MONITORING REQUIREMENTS
RESPONSIBILITIES AND TECHNICAL SUPPORT**

I RADIOACTIVE AMBIENT AIR MONITORING PROGRAM (RAAMP)

The RAAMP has been in operation since the early 1970's. It consists of a network of 28 air sampling stations located on the RFP (Onsite Samplers), locations on the RFP perimeter (14 Perimeter locations) and 14 samplers located in the community surrounding the RFP (Community samplers). Laboratory analysis for specific radionuclides is obtained from the samples acquired at these locations. The Colorado Department of Health (CDH) monitors a similar independent network of air samplers at RFP and in adjacent community locations. The scope of the RAAMP is environmental surveillance, reporting, and compliance.

The RAAMP is managed through the Air Programs Group (APG) of the Environmental Monitoring Division (EMAD). EMAD is a division of the RFP Environmental Management Department. The EMAD APG Manager directs the RAAMP Manager in the functioning of the network. The RAAMP Manager is responsible for maintaining the network to ensure compliance with environmental protection requirements contained in DOE Order 5400.1 "General Environmental Protection Program".

Specific responsibilities of the RAAMP Manager that are relevant to the IPPCD include the following:

- o Prepare a monthly ambient air report for inclusion in the RFP Monthly Environmental Monitoring Report.
- o Schedule weekly air sampler inspection, biweekly air sampler filter collection, required sampler maintenance, air sampler calibrations, and purchase supplies required for RAAMP air sampler operation and sample collection.
- o Scheduling the analysis of sample filters and screening analytical results.
- o Calculate the air sample volume data with the sampler calibration information.

**II LOCAL MONITORING OF TOTAL SUSPENDED PARTICULATE (TSP) AT
INDIVIDUAL ACTIVITY SITES**

Monitoring of Total Suspended Particulate (TSP) at individual activity sites has become a part of the Environmental Restoration Program at RFP since implementation of the 881 Hillside Phase 1-B

Restoration. At the time of Phase 1-B Restoration, concerns for public safety voiced by CDH, EPA and the public prompted development of a technique for measuring suspended particulate concentration on real-time basis. The technique has been refined slightly in the IPPCD so that Total Suspended Particulate (TSP) is monitored rather than RSP. The technique relies upon measuring suspended particulate matter in the immediate vicinity of the emission source and comparing the measurements with trigger levels developed in each Site-Specific Health and Safety Plan. The trigger level concentration is established to provide protection for workers potentially exposed to hazardous contaminants in soils. This measurement versus criterion approach, in conjunction with other operational constraints (wind speed, soil moisture content, etc.), has been applied successfully at the 881-Hillside Phase 1-B Restoration project.

TSP monitoring (also referred to as "Lo-Vol" air samplers) is the responsibility of the individual Project Manager. The Project Manager can either conduct TSP monitoring himself/herself or delegate the function to the Site Health and Safety Coordinator (SHSC). Normally, the SHSC performs TSP monitoring. The SHSC is assigned by the RFP Safety and Hygiene Department.

Specific responsibilities of the SHSC that are relevant to the IPPCD include the following:

- o Instrument calibration and maintenance.
- o Performing the TSP monitoring activity.
- o Reporting monitoring results to the Project Manager and maintaining required documentation.

Real-time TSP monitoring will be conducted periodically over the duration of activities that have the potential for producing appreciable quantities of suspended particulate matter bearing potentially hazardous substances. Measurements will be conducted at least twice daily. Additionally, emphasis will be placed on obtaining measurements at times when particulate emissions are expected to be greatest (i.e., initiation of intrusive activities, removal of augers, moving of bulk soils, etc.).

III LOCAL HIGH VOLUME AIR MONITORING AT IRA CONSTRUCTION SITES

In cases of earth-moving activities related to IRA construction, the determination to use local Hi-Vol air sampling as well pertinent analysis, sampling duration and quality control requirements will be made at the pre-startup activity review. If the determination to employ local Hi-Vol air sampling is made, a representative from the EMAD APG will be assigned to the PM. APG

monitors meteorology and air quality for the Environmental Management Department. The APG representative will be responsible for operation of the Hi-Vol system establishing any site-specific Hi-Vol monitoring and reporting air monitoring data. Once air monitoring samples have been analyzed and reduced, they will be reported to the PM.

When they are to be employed, Hi-Vol air samplers will be operational and checked before soil moving activities begin. Samplers will be calibrated and deemed operational by the APG. Sample collection frequency, duration and analytical requirements will be established before soil moving activities begin. As a minimum, samples should be collected no less than twice monthly over the period of soil-moving activities.

IV ADDITIONAL WORKER HEALTH AND SAFETY MONITORING REQUIRED BY THE SSH&SP

As required by the IAG and OSHA (29 CFR 1910.120), a Site-Specific Health and Safety Plan is to be developed for each Operable Unit (OU) prior to commencement of activities. Site-Specific Health and Safety Plans are prepared in accordance with the RFP Environmental Restoration Health and Safety Program Plan and Workbook. CDH and EPA have reviewed and commented on the Health and Safety Program Plan and Workbook. Each Site-Specific Health and Safety Plan identifies specific worker health and safety monitoring requirements for the various activities conducted at each OU. When intrusive activities are anticipated, the Site-Specific Health and Safety Plan will identify any additional monitoring requirements in addition to those specified by the IPPCD. Implementation of specific worker health and safety monitoring requirements for the various activities is the responsibility of the SH&SC.

TABLE 1.0
LOCAL AIR MONITORING TRIGGER LEVELS
FOR ²³⁹PLUTONIUM IN SOILS

Soil Activity pCi/gram	1.8 Rem/yr. TSP mg/m ³	DAC/10 TSP mg/m ³
0.001	1060500	200000
0.01	106050	20000
0.1	10605	2000
1	1061	200
5	212	40
10	106	20
20	53	10
40	27	5
60	18	3
80	13	3
100	11	2
200	5	1
400	3	0.5
600	2	0.3
800	1.3	0.3
1000	1.1	0.2
1500	0.7	0.13
2000	0.5	0.10
5000	0.2	0.04
10000	0.1	0.02
20000	0.05	0.01
50000	0.02	0.004
80000	0.013	0.003
100000	0.011	0.002

Trigger levels are for Total Suspended Particulate matter (TSP) concentrations measured in the breathing zone as 8-hour, time-weighted averages. They are based on (1) the Derived Air Concentration (DAC)/10 which DOE recognizes as the criteria for implementing respiratory protection and (2) the RFP ALARA based recommended annual committed effective dose equivalent of 1.8 Rem/year.

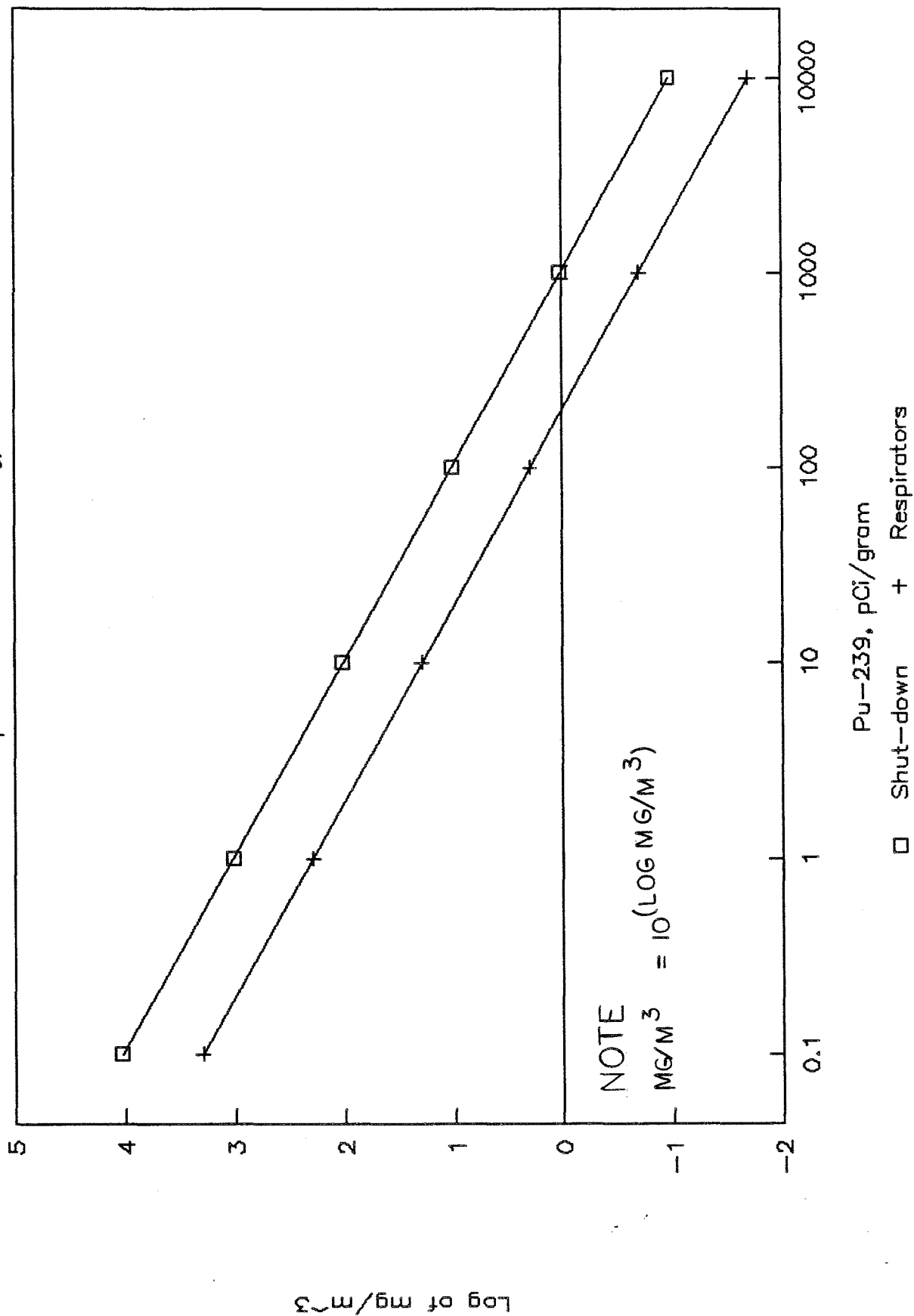
Use of This Table

- 1) Identify the approximate soil activity in the area where intrusive activities are to be conducted.

- 2) Identify the corresponding DAC/10 and annual committed effective dose equivalent (i.e., 1.8 Rem/yr.) trigger levels. Those values represent TSP concentrations that trigger the following actions:
 - A) Donning respiratory protection equipment: DAC/10 threshold
 - B) Stop intrusive actions and reevaluate the activities, conditions, and precautionary requirements
- 3) Measure TSP breathing zone concentrations during intrusive activities using a Piezometric Balance, Mini-Ram, or comparable real-time instrument.
- 4) If measured TSP concentrations attain the trigger levels identified above, for a sustained period of time (15-30 minutes), such that the 8-hour time-weighted average could be approached, follow the appropriate requirements identified above (A or B) and notify the Site Health and Safety Coordinator.
- 5) RFP ALARA practice dictates that reasonable measures be taken to keep exposures to radionuclides as low as reasonably achievable. This implies that routine dust control measures such as local wetting and exposure control mechanisms such as avoiding the leeward dust plume path should be considered, to the extent practicable, regardless of the TSP measurements.
- 6) Environmental concentration measurements and estimates embody uncertainties and can vary at a given location. Thus, users of this table are encouraged to exercise conservative judgement regarding the selection of trigger levels.

FIGURE 1, TRIGGER LEVELS, PU IN SOIL

Total Suspended Particulate, mg/m³





HSP 6.01
Page 1 of 11
July 31, 1989
Replaces: 09/01/87

EXCAVATION PERMIT

1. SCOPE

This practice addresses the responsibilities and required activities for proper use of the Excavation Permit (see Figure HSP 6.01-1) in order to ensure that any excavation is made in a safe and proper manner and that required review by all responsible personnel is documented.

2. APPLICATION

The provisions of this practice apply to all excavations at Rocky Flats Plant, with the exception of emergencies. In the case of an emergency, work may be started without an Excavation Permit with the approval of the Shift Superintendent. This work shall be documented and coordinated in the same manner as for a routine Excavation Permit, by the function performing the work, and a formal Excavation Permit request shall be initiated within 24 hours after the beginning of the emergency.

3. DEFINITIONS

Permit Requester

Any responsible user who initiates an Excavation Permit (RF 46635) request.

Job Supervisor

Operative manager of personnel who dig the excavation and shore, as required.

Solid Waste Management Unit (SWMU)

An inactive waste disposal area as defined in the Resource Conservation and Recovery Act (RCRA). These areas represent known and unknown hazards to human health and the environment.

ROCKY FLATS EXCAVATION PERMIT

12/13/1983

LOCATION/PROJECT TITLE/WORK DESCRIPTION: _____

CONTRACTOR: _____ CONTRACT DWG/SHEET NO: _____

AUTHORIZATION NO: _____ PERMIT NO: _____ DRAWING NO: _____

CAUTIONS/CBSTRUCTIONS/SPECIAL INSTRUCTIONS: _____

LOCATOR TAPE ISSUED: _____ PERMIT LIMITS (DURATION/BOUNDARY) _____

RADIATION MONITORING SURVEY/RESULTS: _____

APPROVALS

RCRA: _____

FE(PCSE)	PLANT POWER	UTILITIES	ALARMS SUP.	TELECOM	COMM SUP.	PLANT PROTECTION

FIRE DEPT	ENVIRONMENTAL	LIQUID WASTE	IND. SAFETY	BUILDING SUPERINTENDENT	INDUSTRIAL HYGIENE	HSE AREA ENGR / SHIFT SUPER

RESPONSIBLE JOB SUPERVISOR: _____

OPERATOR: _____

EXCAVATION COORDINATOR: _____ DATE: _____

INITIAL INSPECTION

BY:

DATE:

DAILY

INITIALS:

DATE:

NOTES:

ATTACH DRAWING SKETCH
SEE REVERSE SIDE FOR ADDITIONAL
INSTRUCTIONS

DISTRIBUTION:

WHITE: C.M.C. FILE
BLUE: FE (PCSE)
YELLOW: HS&E
CARD: JCB SITE

SP 45635 (Rev 7/89) Supersedes Previous Issues

Figure HSP 6.01-1. Excavation Permit

4. RESPONSIBILITIES

4.1 Job Supervisor/Construction Management (CM) Excavation Coordinator

The Job Supervisor/CM Excavation Coordinator is responsible for the following:

- o Ensuring that a properly completed Excavation Permit is issued prior to the start of any excavation, or driving of rods deeper than two feet.
- o Obtaining Excavation Permits for Contractors.
- o Performing daily inspections of all plantsite excavations in process.
- o Performing pre-entry inspections of excavations which require shoring or other means of protection.
- o Reviewing the map of SWMUs provided by Environmental Restoration. Locations of SWMUs are to be considered approximate and caution should be used when excavating near a unit.
- o Submitting a sketch of drawing(s) depicting the excavation site, along with the Excavation Permit request to Facilities Engineering (PCSE) for approval. The drawing(s) shall remain with the Excavation Permit request through the review and approval process.

4.2 H&S Area Engineer

The H&S Area Engineer is responsible for the following:

- o Setting the limits of the Excavation Permit, using input from permit-coordinating activities.
- o Determining the review/signature requirements for the Excavation Permit.
- o Determining, and indicating on the Excavation Permit, whether a survey by Radiological Operations is required.

4.3 Facilities Engineering/Plant Civil Structural Engineering (PCSE)

Facilities Engineering/PCSE is responsible for the following:

- o Reviewing and dispositioning the Excavation Permit request and its accompanying documentation.
- o Assigning the Excavation Permit request a control number and providing the permit requester and CM Excavation Coordinator with an updated Site Utility Drawing or sketch of the area.
- o Accompanying the permit requester, CM Excavation Coordinator, and operator(s) on a walk-through of the worksite to:
 - 1) Visually inspect for obvious obstructions.
 - 2) Discuss methods of execution.
 - 3) Locate utilities by painting or staking their location.

4.4 Environmental Restoration

Environmental Restoration is responsible for reviewing and approving excavations in any SWMU.

5. WORK PRACTICES

5.1 Submitting the Excavation Permit Request

The Job Supervisor or CM Excavation Coordinator shall submit with the Excavation Permit request a sketch or drawing(s) depicting the excavation site to Facilities Engineering/PCSE for approval.

5.2 Notifications

5.2.1 Job Supervisor

The Job Supervisor/CM Excavation Coordinator must be notified, at least 72 hours in advance, of all excavations prior to the start of the job.

5.2.2 Fire Department

Notify the Fire Department for either of the following:

- o If excavations are expected to be deeper than nine feet (X4336).
- o In the event of fire, cave-in or medical emergency (X2911).

5.2.3 Solid Waste Management Unit (SWMU) Notifications

See Paragraph 5.4.6 for SWMU notifications.

5.3 Personal Protective Equipment

Required personal protective equipment shall be identified on the H&S Work Permit, per HSP 6.05, "Radiological/H&S Work Permits."

5.4 Preplanning

5.4.1 Minimum Distance for Spoil Placement

The spoil from any excavation shall be placed a minimum of four feet from at least one side of the excavation lip. This will allow a clear area for rescue equipment.

5.4.2 Excavating Near Security Fences

When an excavation will be near or pass under a security fence, prior notification must be given to Plant Protection. This shall ensure that appropriate security is maintained at all times.

5.4.3 Providing Safe Access/Egress to/from Excavations Deeper than 4-Feet

Make adequate provision for safe access to and egress from any excavation deeper than four feet. Ladders shall be placed to limit travel distance to a maximum of 25 feet. Use ladders of sufficient length to extend from the bottom of the trench to at least 3 feet above the surface of the ground.

5.4.4 Reviewing Drawings/Sketches

Review reference drawings and/or sketches provided by PCSE. Depth and locations of obstructions listed or indicated on reference drawings issued in conjunction with the permit are to be considered approximate.

5.4.5 Excavating Near Known Obstructions

Excavation should be done with extreme caution when performed within 3 feet (horizontal and vertical) of any known obstruction. Exploration to determine the exact location and depth shall be performed near existing utilities by probing or by digging with hand-held shovels.

5.4.6 Excavating in SWMUs

Read the description of the SWMU unit to obtain information on known or potential site hazards.

1) For Non-Emergency Immediate Need Excavation in SWMUs

Notify Environmental Restoration, Industrial Hygiene, and Radiological Operations of the area and need as soon as possible. These groups shall determine appropriate worker and environmental safety precautions.

2) For Emergency Excavation in SWMUs

Follow procedures for workers and environmental safety, as provided by Industrial Hygiene and Radiological Operations. Notify the Shift Superintendent.

5.4.7 Excavating With Heavy Equipment

When excavation is being performed with heavy equipment, a second person, in addition to the operator, shall be stationed within viewing distance of the excavation to visually verify any unusual changes in excavation material such as clay to sand, concrete, locator tape, etc.

5.4.8 When Utility Line Burial is Involved

If utility line burial is involved, a metallic-backed, orange-colored locator tape shall be installed with the utility line, in accordance with Facilities Engineering requirements.

5.4.9 Noting Existing Utilities on the Site Utility Drawing

As work progresses, the CM Excavation Coordinator shall note the location of existing utilities on the Site Utility Drawing(s), and whether that location differs from the drawing. All new utilities shall be annotated on the drawing.

5.4.10 Encountering Unusual Substances

If any unusual substances, odors, liquids or materials are encountered during excavation, notification shall be made to Environmental Restoration, Industrial Hygiene, and Radiological Operations.

5.4.11 Protecting or Barricading the Excavation

Adequately protect or barricade the excavation at all times. Protection consists of physical barriers, such as covers, fencing, planking, railing and warning/caution signs and lights.

5.4.12 Working Near Loads or Earthmoving Equipment

Do not work under or near loads, or earthmoving equipment.

5.5 Special Assistance

5.5.1 Encountering Buried Objects or Suspect Liquids

Obtain Radiological Operations, Environmental Restoration, and Industrial Hygiene assistance if any buried objects or liquid from possible broken or leaking buried lines are encountered.

5.5.2 Encountering Unidentified Obstructions

When unidentified obstructions are encountered, immediately stop the excavation work and notify the responsible Job Supervisor or CM Excavation Coordinator to request assistance from Facilities Engineering (PCSE) to identify the obstructions. PCSE shall use this input to update the Master Site Utility Drawings.

6. SHORING REQUIREMENTS

6.1 Concurrence with OSHA Standard

Shoring requirements shall concur with OSHA 29 CFR 1926.

6.2 Shoring and Shaping

Unless the excavation is in solid rock, shore the sides of all excavations five feet or more deep, or shape to the proper angle of repose at any location where personnel entry is required.

6.3 Specification

The length of the shored or shaped work location must include the effective work zone, plus a safety zone equal in length to the depth of the trench on either side of the work zone. A trench shield may also be used when appropriate (see Figures HSP 6.01-2 and HSP 6.01-3).

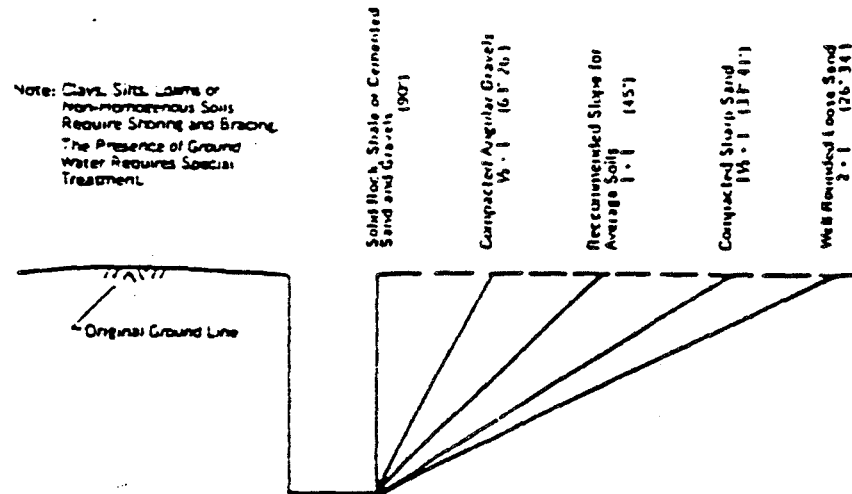


Figure HSP 6.01-2. Approximate Angle of Repose for Sloping of Sides of Excavations

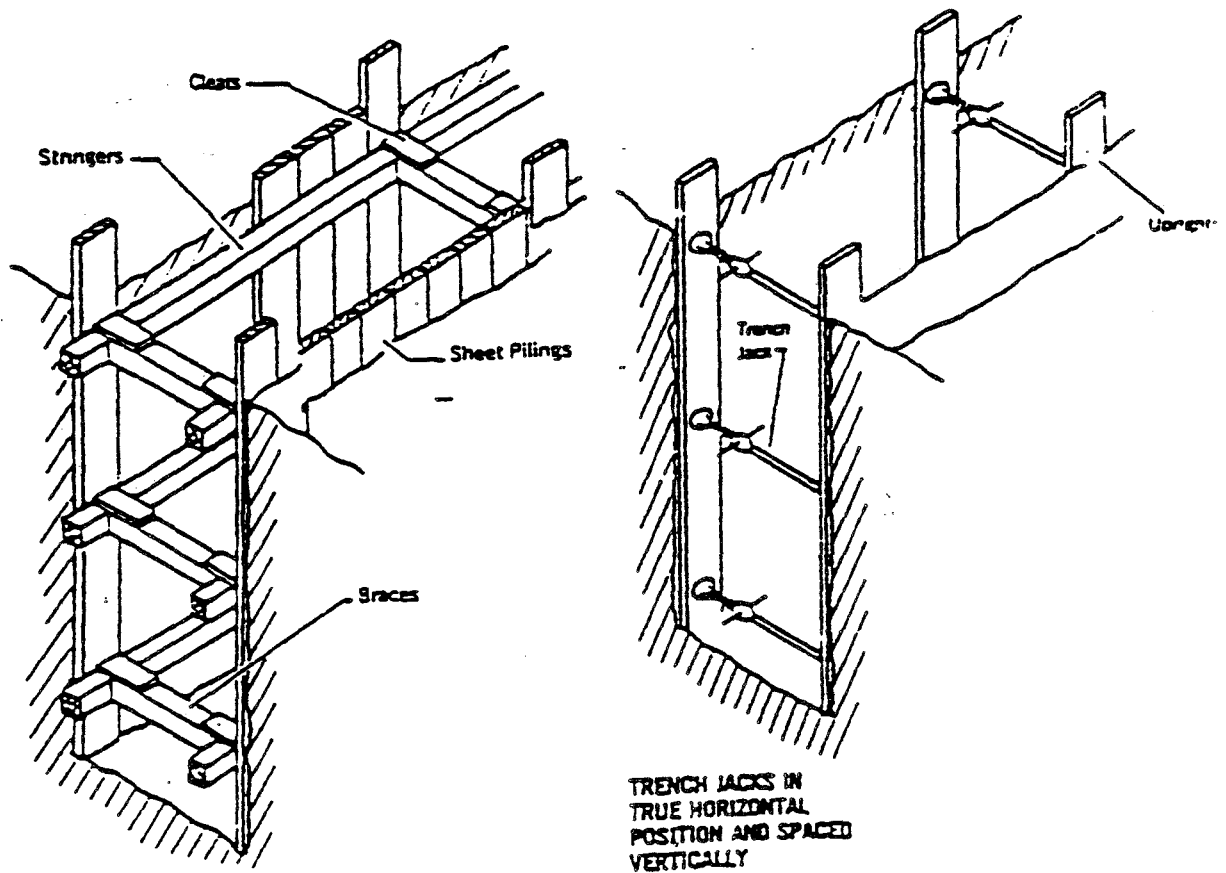


Figure HSP 6.01-3. One Example of Several Types of Sheet piling

6.3.1 Use of Trench Jacks

Instead of wooden timbers, trench jacks may be used for shoring if they are used in accordance with the manufacturer's capacity specifications.

6.3.2 Plywood or Wooden Sheeting

Plywood or other wooden sheeting shall not be less than 3/4 inch; piling or shoring shall not be less than necessary to support the side of the excavation. For additional information, see OSHA 29 CFR 1926, Subpart P, Table P-2.

6.3.3 Use of Prefabricated Moveable Trench Shield

Use of a prefabricated moveable trench shield may be substituted for shoring, if the specific application is approved by the H&S Area Engineer or the CM Excavation Coordinator.

6.4 Shoring an Entire Excavation

If the entire excavation is to be shored, shore the excavation as the digging proceeds. Place the shoring as close to the end of the excavation as the excavating equipment shall permit. Install shoring from the top down; remove shoring from the bottom up.

6.5 Inspection Frequency and Protection Levels

Inspect all excavations daily and especially after storms or other hazard-increasing occurrences; increase the protection against slides and cave-ins, as required.

6.6 Inspection and Approvals Prior to Personnel Entry

Prior to the initial entry by personnel into a shored excavation, the CM Excavation Coordinator, a representative from Occupational Safety, and the H&S Area Engineer must inspect the shoring and shoring technique and sign off on the posted copy of the Excavation Permit. If there is a change to the excavation or shoring configuration as the job progresses, this inspection must be redone.

6.7 Updating the Drawing When Required

Upon job completion, the CM Excavation Coordinator shall provide the updated drawing, marked with horizontal and vertical coordinates locating the line(s). PCSE shall, in turn, update the Master Site Utility Drawing. If difficulty is encountered in locating the XYZ coordinates, the CM Excavation Coordinator shall contact PCSE for assistance.

6.8 Additional Information

For additional information on safety for excavations and trenches,
see OSHA 29 CFR 1926.

7. FORMS

RF 13010, "Work Permit"

RF 46635, "Excavation Permit"

8. REFERENCES

OSHA 29 CFR 1926, "Construction Industry Standards"

HSP 6.05, "Radiological/H&S Work Permit"

RFP Inactive Waste Units, Reference: May, Chen and Associates

HEALTH & SAFETY PRACTICES
Excavation Permit

HSP 6.01
Page 11 of 11
July 31, 1989

CONCURRING SIGNATURES:

J. L. Alvarez

J. L. Alvarez
Plant Health Physicist

7-20-89

Date

J. L. Hebert

J. L. Hebert
Manager, Facilities Project Management

7/21/89

Date

T. F. Lewis

T. F. Lewis
Manager, Industrial Hygiene

7/25/89

Date

S. A. Marshall

S. A. Marshall
Manager, Construction Management

7/20/89

Date

K. B. McKinley

K. B. McKinley
Manager, RCRA/CERLA Program

7/18/89

Date

F. P. McMenus

F. P. McMenus
Manager, Liquid Waste Management

7/18/89

Date

K. F. Miller

K. F. Miller
Manager, Fire Department

7/18/89

Date

R. L. Newby

R. L. Newby
Manager, Plant Protection

7/20/89

Date

G. H. Setlock

G. H. Setlock
Manager, Environmental/Health Programs

7/26/89

Date

J. D. Weaver

J. D. Weaver
Manager, HS&E Area Management

7/14/89

Date



HSP 6.05
Page 1 of 17
June 20, 1990
Replaces: 11/15/89

RADIOLOGICAL/H&S WORK PERMIT

1. SCOPE

This practice establishes the requirements and responsibilities for issuing a Radiological/H&S Work Permit (see Figures HSP 6.05-1, 2, and 3). A Radiological/H&S Work Permit identifies the necessary precautions to be taken for the safety and health of personnel and the protection of property.

2. APPLICATION

Radiological/H&S Work Permits are required for jobs specified in Section 5.

3. DEFINITIONS

Job Supervisor

The immediate supervisor of the employees performing the work. For contractor work, the Job Supervisor is the Construction Management (CM) Coordinator.

Responsible User

The supervisor who normally controls the area or equipment.

Job Personnel

The employees actually performing the work described on the Radiological/H&S Work Permit.

4. GENERAL RESPONSIBILITIES

4.1 Job Supervisor

The Job Supervisor is responsible for initiating a Radiological/H&S Work Permit when required, for coordinating the completion of the permit, for ensuring the overall safety of the job, and for complying with the requirements of this practice.

RADIOLOGICAL/HEALTH & SAFETY WORK PERMIT <small>Instructions and requirements for the use of this form are contained in H&S 6.05 Radiological/H&S Work Permit</small>		
SECTION I - JOB INFORMATION (To be completed by job supervisor or permit initiator)		
Job Name _____ Auth or WO # _____		
Bldg. _____ Room # _____ Date _____ From _____ (AM/PM) To _____ (AM/PM)		
Scope of Work _____		
SECTION II - DESCRIPTION OF HAZARDS (To be completed by responsible user)		
MATERIAL HAZARDS <input type="checkbox"/> HNO ₃ (Nitric Acid) <input type="checkbox"/> HCl (Hydrochloric Acid) <input type="checkbox"/> H ₂ SO ₄ (Sulfuric Acid) <input type="checkbox"/> HF (Hydrofluoric Acid) <input type="checkbox"/> Caustic <input type="checkbox"/> Flammables <input type="checkbox"/> Trichloroethylene <input type="checkbox"/> Beryllium <input type="checkbox"/> Plutonium <input type="checkbox"/> Uranium <input type="checkbox"/> Asbestos	ELECTRICAL HAZARDS Energized System? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> 120V <input type="checkbox"/> 220V <input type="checkbox"/> 480V <input type="checkbox"/> 600V <input type="checkbox"/> Above 600V <input type="checkbox"/> _____ V <input type="checkbox"/> Laser Involved? <input type="checkbox"/> Microwave Involved?	HIGH TEMP/HIGH PRESSURE <input type="checkbox"/> Vacuum <input type="checkbox"/> Ambient Pressure <input type="checkbox"/> <15 psig <input type="checkbox"/> >15 psig <input type="checkbox"/> _____ psig <input type="checkbox"/> Below Ambient Temp <input type="checkbox"/> _____ °F <input type="checkbox"/> Ambient Temp <input type="checkbox"/> Above Ambient Temp <input type="checkbox"/> _____ °F <input type="checkbox"/> Steam System <input type="checkbox"/> Hydraulic System
Fire Suppression Interruption? <input type="checkbox"/> Yes <input type="checkbox"/> No		
Other hazards and precautions _____		
SECTION III - RADIOLOGICAL AND NONRADIOLOGICAL SAFETY REQUIREMENTS (To be completed by Radiological Protection, and/or H&S Area Engineer).		
JSA REQUIRED <input type="checkbox"/> Yes <input type="checkbox"/> No JOBSITE REVIEW REQUIRED <input type="checkbox"/> Yes <input type="checkbox"/> No		
A PACKAGE REQUIRED <input type="checkbox"/> Yes <input type="checkbox"/> No RADIOLOGICAL PROTECTION TECHNOLOGIST (RPT) REQUIRED <input type="checkbox"/> YES <input type="checkbox"/> NO		
PROTECTIVE APPAREL <input type="checkbox"/> Coveralls <input type="checkbox"/> Tyvek Suit <input type="checkbox"/> Plastic Suit <input type="checkbox"/> Acid Suit <input type="checkbox"/> Surgeon's Gloves <input type="checkbox"/> Plastic Gloves <input type="checkbox"/> Rubber Gloves <input type="checkbox"/> Leather Gloves <input type="checkbox"/> Cloth Cap <input type="checkbox"/> Cloth Hood <input type="checkbox"/> Plastic Hood <input type="checkbox"/> Booties <input type="checkbox"/> Plastic Booties <input type="checkbox"/> Rubber Boots <input type="checkbox"/> Safety Glasses <input type="checkbox"/> Goggles <input type="checkbox"/> Face Shield <input type="checkbox"/> Hard Hat <input type="checkbox"/> Hearing Protection <input type="checkbox"/> Taped Openings <input type="checkbox"/> Other _____	RESPIRATORY REQUIREMENTS <input type="checkbox"/> Half Mask <input type="checkbox"/> Full Face <input type="checkbox"/> Supplied Breathing Air <input type="checkbox"/> SCBA <input type="checkbox"/> Chemical Canister RADIOLOGICAL PROTECTION REQUIREMENTS <input type="checkbox"/> Start of job <input type="checkbox"/> On call <input type="checkbox"/> Full time DOSIMETRY REQUIREMENTS <input type="checkbox"/> TLD Dosimeter <input type="checkbox"/> Extremity Dosimeter <input type="checkbox"/> Special Dosimeter ELECTRICAL PROTECTION REQUIREMENTS (Consult Job Supervisor) <input type="checkbox"/> Insulating Mat <input type="checkbox"/> Insulating Blanket <input type="checkbox"/> Cover up <input type="checkbox"/> High Voltage Sleeves <input type="checkbox"/> High Voltage Gloves <input type="checkbox"/> _____ Class I <input type="checkbox"/> _____ Class II <input type="checkbox"/> Hot Sticks <input type="checkbox"/> TIC Tracer <input type="checkbox"/> Insulated Bucket Truck <input type="checkbox"/> Grounding Cable <input type="checkbox"/> Grounding Stick	RADIOLOGICAL PROTECTION PRE-JOB SURVEY Contamination levels and extent _____ Gamma _____ Neutron _____ Limitations _____ RPT Signature _____ RADIOLOGICAL PROTECTION POST-JOB SURVEY Contamination levels and extent _____ Gamma _____ Neutron _____ RPT Signature _____ Other Special Requirements _____
CONTAMINATION CONTROL VENTILATION REQUIREMENTS <input type="checkbox"/> Containment Pen <input type="checkbox"/> Plastic House <input type="checkbox"/> SBA House <input type="checkbox"/> Plastic Sleeve <input type="checkbox"/> Glove Bag <input type="checkbox"/> Air Mover <input type="checkbox"/> Down Draft <input type="checkbox"/> GB Exhaust <input type="checkbox"/> Other _____		

Figure HSP 6.05-1. Radiological/H&S Work Permit, Page 1

INSTRUCTIONS FOR COMPLETING RADIOLOGICAL/HEALTH & SAFETY WORK PERMIT

(Refer to H&S 6.05, Radiological/Health & Safety Work Permit procedure for full explanation)

SECTION I - Job Information

This section is to be completed by the job supervisor (the immediate supervisor of the employees performing the work) or a designated permit initiator. For contractor work, the job supervisor is the CM coordinator.

JOB NAME: Enter name of job as it appears on work order or construction package.

AUTH OR WO#: Enter authorization or work order number.

BLDG. and ROOM #: Enter the building and room number in which the work will be performed.

DATE, FROM, and TO: Enter the start date and times for which the permit is valid.

SCOPE OF WORK: Enter a brief description of the work to be performed during the duration of this permit.

SECTION II - Description of Hazards

This section is to be completed by the responsible user (the supervisor who normally controls the area or equipment). Indicate what hazards may be present in the systems on which the work will be performed and in the surrounding area.

MATERIAL HAZARDS: Check what chemical and material hazards exist. Write in any other hazards that are not listed.

ELECTRICAL HAZARDS: Check whether the subject systems will be energized when the work is performed. Check the voltage level if applicable and if a laser or microwave hazard exists.

HIGH TEMP/HIGH PRESSURE: Indicate the temperature and pressure of the subject systems.

FIRE SUPPRESSION INTERRUPTION: Indicate if the fire suppression system in the area will be interrupted.

OTHER HAZARDS AND PRECAUTIONS: Enter any other hazards and precautions that do not appear elsewhere on the permit.

SECTION III - Radiological and Nonradiological Safety Requirements

This section is to be completed by the H&S Area Engineer and, if the job involves possible radioactive contamination, Radiological Protection. The H&S Area Engineer will determine if a Jobsite Review is required and if Radiological Protection input is required and indicate so at the top of this section.

PROTECTIVE APPAREL: Check the protective apparel required. Consider radiological, chemical, electrical, and other safety hazards when completing this section.

CONTAMINATION CONTROL/VENTILATION REQUIREMENTS: Check any special contamination control or ventilation requirements.

RESPIRATORY REQUIREMENTS: Check respirator requirements for radiological and chemical hazards.

RADIOLOGICAL PROTECTION REQUIREMENTS: Indicate if Radiological Protection coverage is required at the start of job only, on an "on call" basis, or on the job full time.

DOSIMETRY REQUIREMENTS: Indicate dosimetry requirements.

ELECTRICAL PROTECTION REQUIREMENTS: The H&S Area Engineer should consult with the job supervisor in order to complete this section. Indicate electrical protection required.

RADIOLOGICAL PRE-JOB SURVEY: Radiological Protection will survey the work area, complete this section and sign before the job begins.

RADIOLOGICAL POST-JOB SURVEY: Radiological Protection will survey the area at the completion of the job, complete this section and sign.

OTHER SPECIAL REQUIREMENTS: Any safety requirements not covered by the checklists in this section will be noted here.

SECTION IV - Preparation for the Job

The majority of this section is to be completed by the responsible user. The questions concerning lockout and tagout is to be completed jointly by the user and job supervisor.

SECTION V - Approval Signatures

The work will be reviewed with all personnel that will be involved in the job. They will then sign that they understand the permit and the requirements. The job supervisor or responsible user will notify the building manager of the upcoming work and initial the permit. The responsible user, job supervisor, H&S Area Engineer, and any other H&S discipline required by the Area Engineer will sign the permit. When applicable, the Radiological Protection Foreman and contractor supervisor will also sign this section.

SECTION VI - Permit Extension

The permit can be extended beyond one shift only with the permission of the H&S Area Engineer. The job supervisor(s) must tour the work area each working shift of each working day to ensure compliance with H&S requirements and initial Section VI of the white copy and the card copy to indicate this was done.

DISTRIBUTION

Distribute and retain as indicated. Post card at the jobsite, and remove and destroy the card when the permit has expired.

Figure HSP 6.05-2. Instructions for Completing Radiological/H&S Work Permit
(on back of RF 13010)

HEALTH & SAFETY PRACTICES
Radiological/H&S Work Permit

HSP 6.05
Page 4 of 17
June 20, 1990

RADIOLOGICAL/HEALTH & SAFETY WORK PERMIT - CONTINUED	
Auth or WO # _____ Date _____	
SECTION IV - PREPARATION FOR THE JOB (To be completed by the responsible user and job supervisor)	
The area or equipment is ready to be worked on and is in safe condition	_____ Yes
The necessary systems have been shutdown, drained, blanked, etc.	_____ Yes _____ N/A
The necessary systems have been locked out/tagged out. # _____	_____ Yes _____ N/A
Voltage checked after lock out.	_____ Yes _____ N/A
Utilities has been notified of upcoming work and is prepared.	_____ Yes _____ N/A
The Fire Department has been notified of upcoming work and is prepared.	_____ Yes _____ N/A
SECTION V - APPROVAL SIGNATURES	
THE ABOVE REQUIREMENTS HAVE BEEN REVIEWED WITH AND ARE UNDERSTOOD BY ALL JOB PERSONNEL.	
(Job personnel signatures)	
The Building Manager (or designee) has been notified of upcoming work _____ (notifier's initials)	
THE SIGNATURES BELOW INDICATE REVIEW AND CONCURRENCE WITH THE WORK PERMIT.	
Responsible User _____	Job Supervisor _____
RPT Foreman (if applicable) _____	Contractor Supervisor (if applicable) _____
H&S Area Engineer _____	Other _____
SECTION VI - PERMIT EXTENSION	
WORK PERMIT EXTENDED TO: _____ H&S Area Engineer	
Job Supervisor agrees to tour area daily to ensure compliance with H&S requirements. (Initials required for each day of extension)	
Dates: _____	
Initials: _____	

DISTRIBUTION

Job Supervisor -	White (retain permanently with job file)
Responsible User -	Blue (retain for 30 days)
Radiological Protection -	Yellow (retain for 30 days)
H&S Area Engineer -	Green (info copy)

POST CARD AT JOB SITE

FIRE AND EMERGENCY - DIAL 2911

Page 2 of 2

4.2 Responsible User :

The Responsible User must comply with these requirements and is responsible for communicating to the workers any hazard that exists in the area.

4.3 Job Personnel

Job personnel shall comply with these requirements and the precautions specified on the H&S Work Permit.

4.4 H&S Area Engineer

The H&S Area Engineer reviews and signs all Radiological/H&S Work Permits and ensures review by the H&S disciplines and the Fire Department, when necessary.

4.5 Operations Manager

The Operations Manager, who is notified of all work covered by a Radiological/H&S Work Permit shortly before the work begins, has the authority to modify or halt work plans.

5. **REQUIRED PERMITS AND REVIEW**

A Radiological/H&S Work Permit is required for the following jobs:

5.1. Breaking the Primary Containment of a Radioactive System

When breaking the primary containment of a radioactive system, except for routine work which is covered by an H&S-approved practice.

Work permits for this type of work require concurrence from Radiological Operations.

5.2 Work Using Breathing Air

When personnel perform work using breathing air, i.e., self-contained or supplied air, except for work which is covered by an H&S-approved practice.

5.3 Work Inside Plenums, Ducts, Gloveboxes

When personnel shall be working inside plenums, ducts, or gloveboxes. "Working inside" is interpreted as the entire body being inside the duct, glovebox or plenum. In such cases, the permit must be reviewed and signed by the Operations Manager as the Responsible User.

5.4 Work on Air-Handling Systems, Air Stacks

For any work on air-handling systems, including opening of exhaust systems, or work on air stacks, etc.;, except for pre-filter changing of room-air exhaust ducts, heating, ventilating, and supply plenums.

5.5 Glovebox and Hood Filter Changes

For glovebox and hood filter changing.

5.6 Work on Radioactive Sources

For any work on radiation-producing devices or systems containing radioactive sources except alpha-mets and combos (combination hand/foot checking instruments).

5.7 Exhaust and Plenum Filter Changing

For exhaust and recirculating plenum filter changing.

5.8 Physical Changes to Potable Water or Process Drainage

For any physical changes to potable water or process drainage.

5.9 Interruption of Environmental Samplers

For interruption of environmental samplers.

5.10 Work on Exposed Electrical Systems

For work on exposed electrical systems, as follows:

- o High voltage (>600 V-AC), energized or de-energized.
- o Repair of any energized electrical system.
- o Troubleshooting, testing, or calibrating any energized electrical system, except when both of the following two conditions are met:

The work is performed by one of the following crafts:
Alarm/Telecommunications Technician; Auto Mechanic/Vehicle Modification Mechanic (vehicles only); Electrician Technician; Electronics Technician; Lineman-Electrician; Electrician; Qualified Support Engineers; Metrology Technicians;

and

The craftsperson/qualified Support Engineer has been trained in safe work practices of electrical systems/equipment, is aware of electrical hazards and the necessary protective requirements, and the training is documented.

5.11 Specified Interruption of Electric Power

For interruption of electric power affecting more than the piece of equipment being worked on, except for scheduled power outages.

5.12 Specified Nonroutine Hoisting/Rigging of Equipment

For nonroutine hoisting/rigging of equipment during construction or maintenance operations, such as gloveboxes, machinery, transformers or other critical equipment.

5.13 Possibility of Specified Contaminant Release

For any job where the possibility exists for a radioactive or hazardous contaminant release to the outside environment, either by air, liquids, or solids.

5.14 Known or Suspected Beryllium/Asbestos Contamination

Where beryllium or asbestos contamination is known or suspected to be present or would be released during the work activity, except for routine production operations which are covered by an H&S-approved practice.

5.15 Potential for Hazard Exists

Where a hazard is suspected to exist or could be created, such as work involving high pressure (greater than 15 lbs per sq. in.), high temperature (greater than 200°F), caustics, acids, or other hazardous materials per HSP 9.07, "Written Hazard Communications Program."

5.16 Temporary Reassignment of Equipment

For temporary reassignment to Maintenance of the responsibility for an area or piece of equipment.

5.17 Operating Mobile Cranes Outside Designated Construction Area

When operating mobile cranes outside of the designated construction area and near existing structures or recognized hazards, e.g., near overhead power lines and surfaces.

5.18 When Requested by the Originator of the Permit

If requested by the originator of the permit, any employee involved in the preparation or execution of the job, the Job Supervisor, the Responsible User, an H&S Area Engineer, any H&S discipline, or the Fire Department.

5.19 Painting with Flammable-Based Paints

For any painting with flammable-based paints (see HSP/FLP 34.04).

5.20 Specified Ladder/Scaffold Work in a Controlled Area

All work performed in a Controlled Area from a ladder or scaffold not covered by an H&S approved procedure.

6. **RESPONSIBILITIES AND REQUIREMENTS**

6.1 Issuance

The Job Supervisor shall ensure that a Radiological/H&S Work Permit is issued when required (see Section 5).

6.2 How to Complete the Radiological/H&S Work Permit

Figure HSP 6.05-4 summarizes the activities in completing a Radiological/H&S Work Permit. The instructions for completing the permit are as follows:

6.2.1 **Section I: Job Information**

6.2.1.1 This section is to be completed by the Job Supervisor. For contractor work, the Job Supervisor is the CM Coordinator.

JOB NAME: Enter the name of job as it appears on the work order or construction package.

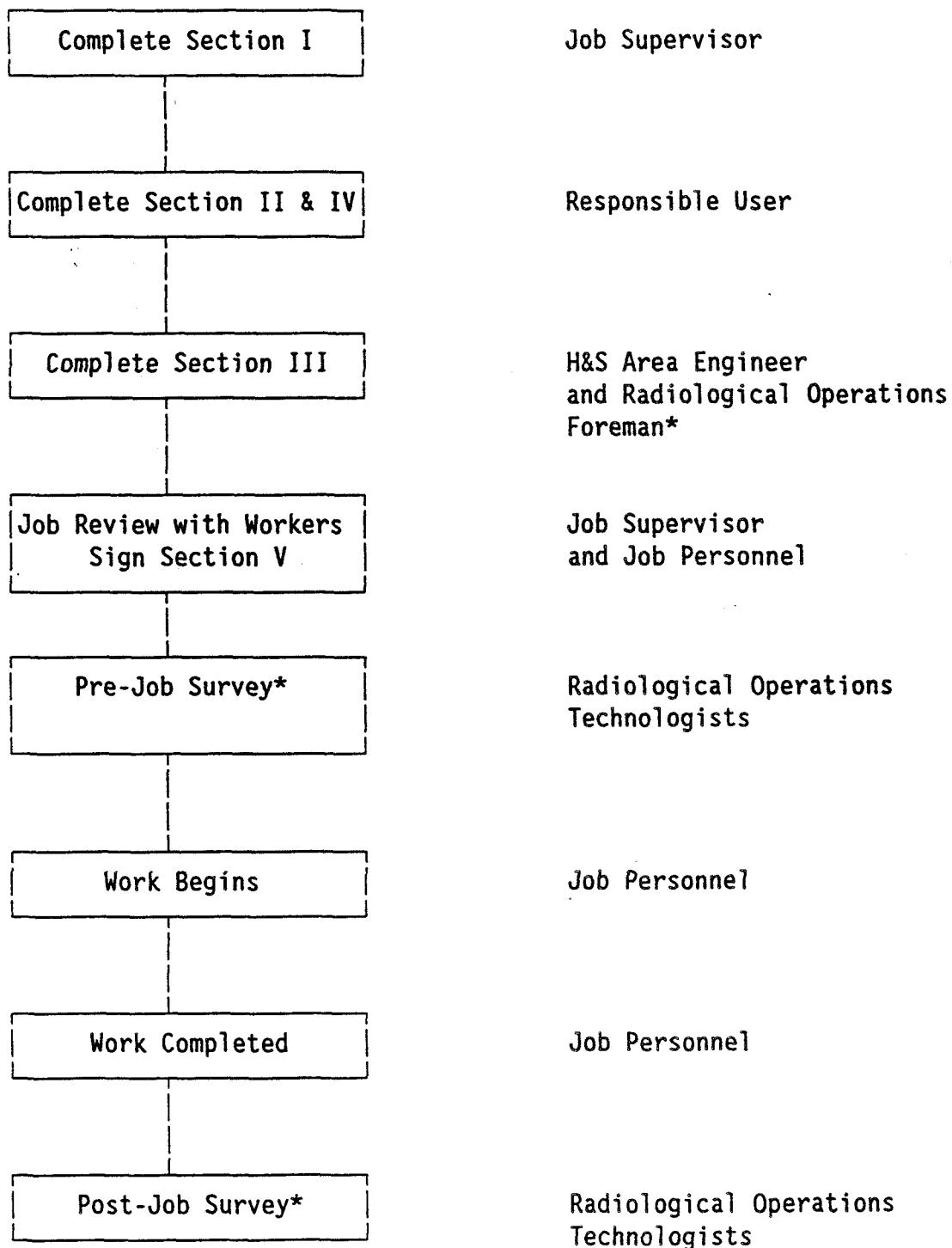
AUTH OR WO#: Enter the authorization or work order number.

BLDG. and ROOM#: Enter the building and room number in which the work will be performed.

DATE, FROM, and TO: Enter the start date and times for which the permit is valid.

SCOPE OF WORK: Enter a brief description of the work to be performed during the duration of the permit. Identify any related work instructions such as an "A" or "B" package, Job Safety Analysis (JSA) or other written instructions and submit to the H&S Area Engineer for review with the permit, including only that portion of the work to be covered by the work permit. Specify the location of the worksite using established identifiers such as column numbers, glovebox numbers or electrical panel numbers. Fixed Price and CPFF construction contracts shall not require the "A" or "B" package for authorization work. The JSA or written instructions requirement shall be determined on a case-by-case basis by the H&S Area Engineer and Construction Safety. Other activities requiring a work permit shall be determined on a case-by-case basis by the H&S Area Engineer.

RESPONSIBILITY



* Required only if working in an area of potential radioactive contamination.

Figure HSP 6.05-4. Flowchart for Radiological/H&S Work Permit

6.2.2 Section II: Description of Hazards and Section IV - Preparation for the Job

The Responsible User completes Sections II and IV.

- 6.2.2.1 In Section II the Responsible User shall describe the hazards that may be present in the systems on which the work will be performed and in the surrounding areas.

MATERIAL HAZARDS: Check what chemical and material hazards exist. Write in any other hazards that are not listed.

ELECTRICAL HAZARDS: Check whether the subject systems will be energized when the work is performed. Check the voltage level if applicable and if a laser or microwave hazard exists.

HIGH TEMP/HIGH PRESSURE: Indicate the temperature and pressure condition of the subject systems and if the system is a steam or hydraulic system.

FIRE SUPPRESSION INTERRUPTION: Indicate if fire suppression in the area will be interrupted.

OTHER HAZARDS AND PRECAUTIONS: Enter any other hazards and precautions that do not appear elsewhere on the permit.

- 6.2.2.2 In Section IV the Responsible User shall answer the questions listed. The Responsible User may request assistance from the Job Supervisor in answering the questions pertaining to lockout and tagout and coordination with Utilities and the Fire Department.

- 6.2.2.3 After completing Sections II and IV, the Responsible User may sign Section V. The Responsible User may wait until the entire permit is completed before signing it.

6.2.3 Section III: Radiological and Nonradiological Safety Requirements

This section is to be completed by the H&S Area Engineer and, if the job involves possible radioactive contamination, Radiological Operations. Radiological Engineering review and approval is required for all work inside a Controlled Area, and for work involving radioactive materials or radiation producing devices outside a Controlled Area.

- 6.2.3.1 The H&S Area Engineer shall review the scope of the job, determine if a job site review is required, and indicate so at the top of Section III.

If a job site review is required, the Job Supervisor, Responsible User, H&S Area Engineer and any other necessary personnel shall visit the job site before completing the H&S Work Permit within 24

hours before the job is to begin. They shall discuss the work to be performed and identify any hazards and safety precautions which must be taken. Relevant safety information from this review shall be entered on the work permit.

- 6.2.3.2 The H&S Area Engineer shall indicate if this job requires an "A" Package or a Job Safety Analysis (JSA) based on the following criteria:

"A" Package

An "A" Package is required for specified Maintenance work as described in Maintenance Procedure 3.4, "Maintenance Department Work Packages," and for the following H&S-related applications:

- o All new authorizations, addenda and Field Change Orders which include site preparation, construction, and installation.
- o Repair, replacement, modification, and/or installation work orders where radionuclide or hazardous contamination exist and/or primary containment is breached.
- o Repairs and replacements of all mechanical and electrical items where systems cannot be locked out.
- o Any construction work on roofs and unguarded elevated platforms over 16 feet above ground or any excavations deeper than five feet.

Job Safety Analysis

A JSA consists of the basic job steps, identification of potential hazards, and precautions which shall be taken, per HSP 2.11, "Job Safety Analysis." A JSA is required for contractor work meeting the following criteria:

- o Construction work on roofs and unguarded elevated platforms over 16 feet above the ground.
- o Construction work involving excavations deeper than five feet.
- o Construction work performed in a radiation Controlled Area or involving hazardous materials with an NFPA rating of 4.

The H&S Area Engineer may request a JSA for any other work not meeting the above criteria if he/she deems it necessary to ensure that the job is completed safely.

6.2.3.3 The "A" Package or JSA shall be available for the H&S Area Engineer to review before the job begins. Preparatory and post-job activities not involving activities defined in Section 5 may be accomplished without a work permit.

6.2.3.4 Multiple Work Permits

Jobs with several unrelated hazards may require the issuance of multiple work permits to authorize performance of specific work segments. When multiple work permits are utilized, the required "A" package or JSA shall have hold points to indicate when a work permit is required.

6.2.3.5 Possible Radioactive Contamination

If the job involves possible radioactive contamination, Radiological Operations input and a pre-job and post-job radiation survey are required. The H&S Area Engineer shall indicate this requirement at the top of Section III.

6.2.3.6 The remainder of Section III shall be completed by the H&S Area Engineer and Radiological Operations as follows:

PROTECTIVE APPAREL: Check the protective apparel required. Consider radiological, chemical, electrical, and other safety hazards when completing this section.

CONTAMINATION CONTROL/VENTILATION REQUIREMENTS: Check any special contamination control or ventilation requirements. (Note: The need for a portable SAAM shall be noted on the "other" line of this section.)

RESPIRATORY REQUIREMENTS: Check respirator requirements for radiological and chemical hazards.

RADIOLOGICAL OPERATIONS REQUIREMENTS: Indicate if Radiological Operations coverage is required at the start of job only, at the start and at the end, on an "on call" basis, or on the job full time.

DOSIMETRY REQUIREMENTS: Indicate dosimetry requirements.

ELECTRICAL PROTECTION REQUIREMENTS: The H&S Area Engineer shall consult with the Job Supervisor in order to complete this section. Indicate electrical protection required.

RADIOLOGICAL OPERATIONS PRE-JOB SURVEY: Before the job begins, Radiological Operations shall survey the work area, complete this section and sign.

RADIOLOGICAL OPERATIONS POST-JOB SURVEY: Radiological Operations shall survey the area at the completion of the job, complete this section and sign.

OTHER SPECIAL REQUIREMENTS: Any safety requirements (e.g., scaffolding or excavation shoring) not covered by the checklists in this section shall be noted here.

6.2.3.7 After completing applicable parts of Section III, the Radiological Operations Foreman shall sign Section V. For those jobs requiring the support of Radiological Operations (RO), the RO Foreman shall review and sign Section V a second time, validating the work permit after the RPT has completed the pre-job survey, and before work commences.

6.2.4 **Section V - Approval Signatures**

The H&S Area Engineer shall review the entire permit and sign Section V.

6.2.4.1 At this point, the first four sections of the Radiological/H&S Work Permit shall be complete except for the pre-job survey and final sign-off by the RO Foreman, when applicable. The permit will have been signed by the Responsible User, the H&S Area Engineer, and when applicable, the RO Foreman.

The permit shall now be reviewed and signed by the Job Supervisor and, if the work is to be performed by contractors, the contractor supervisor.

6.2.4.2 The Job Supervisor shall notify the Operations Manager that the work is ready to begin and shall initial Section V.

6.2.4.3 The Job Supervisor shall review the entire Radiological/H&S Work Permit with all job personnel, and shall emphasize the hazards (Section II) and the safety requirements (Section III). All job personnel shall sign Section V and the work may begin. Any change of job personnel shall require that replacement personnel be briefed and that they sign in Section V.

6.2.5 **Section VI: Permit Extension**

6.2.5.1 The actual work shall proceed during the time specified on the work permit. Normally, a Radiological/H&S Work Permit is issued for only one shift of work unless extended by overtime and/or specifically approved by the H&S Area Engineer.

6.2.5.2 The H&S Area Engineer may authorize an extension of the H&S Work Permit under extreme circumstances after the actual work has started. The extension date shall be entered on the form and the H&S Area Engineer shall sign Section VI. Extensions for CPFF and

Fixed Price Authorization non-radiological work may be granted up to seven consecutive days when the permit is issued, including all three shifts of each day.

6.2.5.3 For all Radiological/H&S Work Permit extensions granted, the Job Supervisor is required to review the work area daily to ensure compliance with health, safety and environmental standards. The Job Supervisor acknowledges that this review has been conducted by entering the date and his/her initials in the blanks provided. If work is being performed on more than one shift, each Job Supervisor on each shift shall initial. Initials and dates shall be entered on the Job Supervisor's white copy of the permit and the posted card copy of the permit.

6.2.5.4 Extensions are subject to cancellation by the H&S Area Engineer if violations to the above requirements are cited.

6.2.6 Changing Conditions

6.2.6.1 If, during the life of the permit, conditions in the job area change or job personnel change, a new work permit is not necessarily required.

o Minor Changes

Minor changes in the work permit can be made as long as these changes are noted on the white copy and card copy of the permit and initialed and dated by the H&S Area Engineer and the changes are clearly understandable after the work permit is modified. Any changes must be reviewed with the job personnel.

o New Personnel

Similarly, any new personnel added to the job during the life of the work permit shall review the permit and sign the white copy and card copy of the permit.

6.2.6.2 Major changes in personnel or job conditions, that cannot be clearly indicated on the existing work permit, may dictate that a new work permit be generated.

6.3 Post-Job Survey

If Radiological Operations was required on the job, a post-job radiation protection survey shall be performed when the job is completed. Prior to the release of an area or item, the survey shall indicate that the area or item has been returned to the fixed and removable levels, per ROI 3.1. The results must be recorded on the last Radiological/H&S Work Permit issued for the job (on the white and yellow copies of the form, as a minimum).

6.4 H&S Review

6.4.1 Regular Shift

The H&S Area Engineer shall review and sign all Radiological/H&S Work Permits and shall coordinate additional review by other H&S disciplines and the Fire Department, if required. All work requiring work permits must be scheduled through the Plan-of-the-Day (POD) meeting where applicable. Ideally, all work for the following day should be identified at the POD and available for review by H&S.

6.4.2 Off-Shifts

On off-shifts, the permit shall be reviewed and signed by the off-shift H&S Area Engineer on duty. Work scheduled for weekends shall be identified at the Friday POD meetings where applicable. This work shall be reviewed after the POD meetings and the applicable work permits signed by the appropriate H&S disciplines by close-of-business (COB) Friday. If a work permit is more than 8-hours old when the work is scheduled to commence, the Job Supervisor shall review the permit to assure that it addresses current conditions.

Another alternative to weekend work is to arrange with the weekend "on-call" H&S Area Engineer to be available at a specific time during the weekend to sign the permit. In the event that no H&S Area Engineer is available, Radiological Operations management or the Shift Superintendent can review the permit and sign for the H&S Area Engineer.

6.5 Distribution, Retention, and Posting

Copies of the permit shall be distributed as indicated on the form. Permits shall be retained permanently with the job file by the Job Supervisor and for 30 days after the original issue date by the Responsible User and Radiological Operations supervision. The card copy of the permit shall be posted at the job site, removed, and destroyed after the permit has expired.

7. FORM

RF 13010, "Radiological/H&S Work Permit"

8. REFERENCES

HSP 2.02, "Plan For ALARA"

HSP 2.08, "Lockout/Tagout"

HSP 24.01, "Safety Responsibilities for Construction Contractors"

HSP/FLP 34.04, "Application of Floor Paint and Sealer"

Mtce 3.4, "Maintenance Work Packages"

ROI 3.1, "Performance of Surface Contamination Surveys"

For additional information on this practice, contact
K. E. Cavin, Radiological Building Engineering, x5151,
or W. R. Richardson, H&S Area Engineering, x2325.

CONCURRING SIGNATURES:

D. W. Ferrera
D. W. Ferrera
Director, Support Services

6/19/90
Date

For K. J. Freiberg
K. J. Freiberg
Manager, Maintenance

6/20/90
Date

D. M. Hardin
D. M. Hardin
Acting Manager, Radiological Operations

6/19/90
Date

K. F. Miller
K. F. Miller
Manager, Fire Department

6/19/90
Date

J. M. Shaffer *for*
J. M. Shaffer
Manager, FPM Program Control

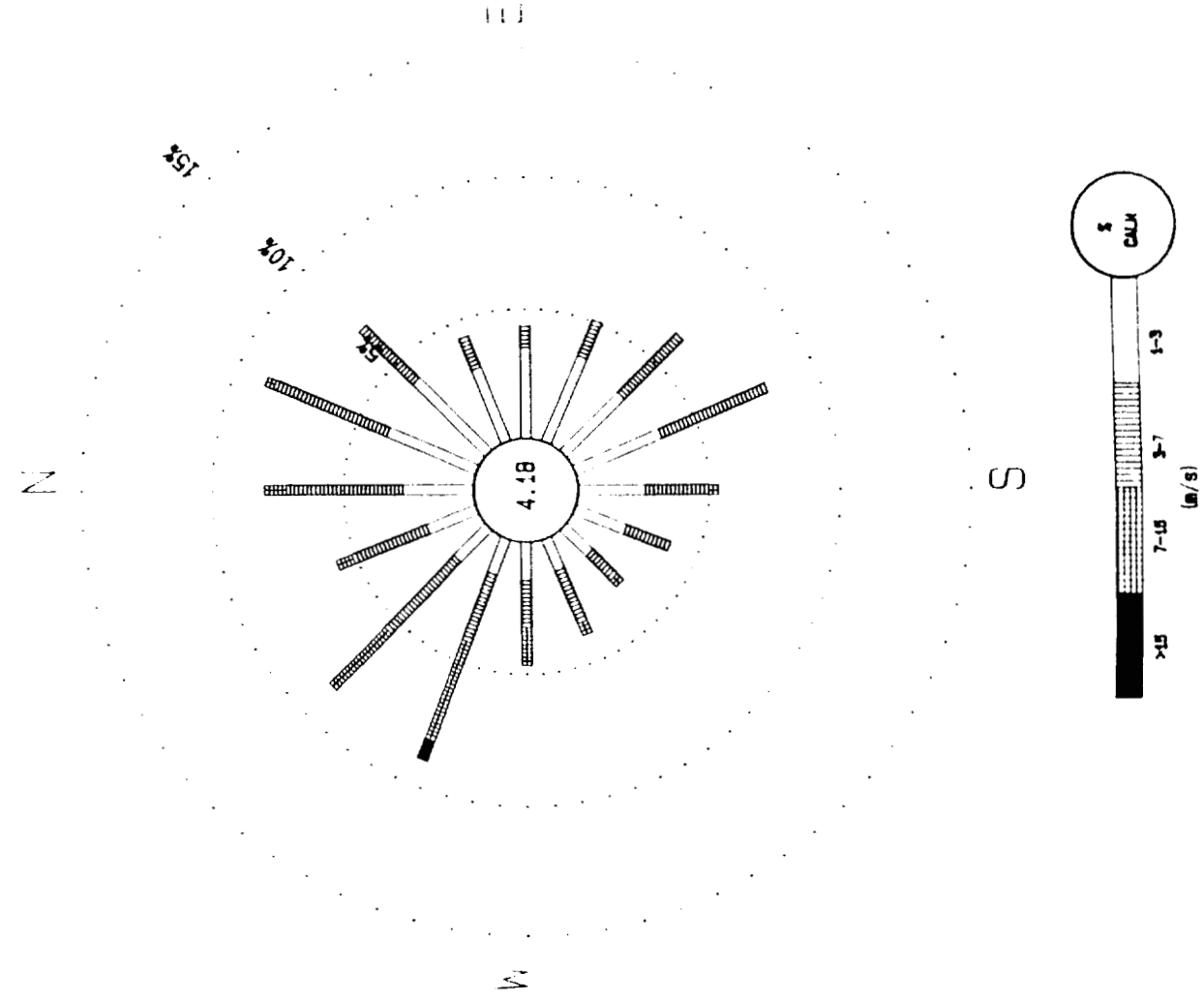
6-19-90
Date

J. D. Weaver
J. D. Weaver
Manager, H&S Area Engineering

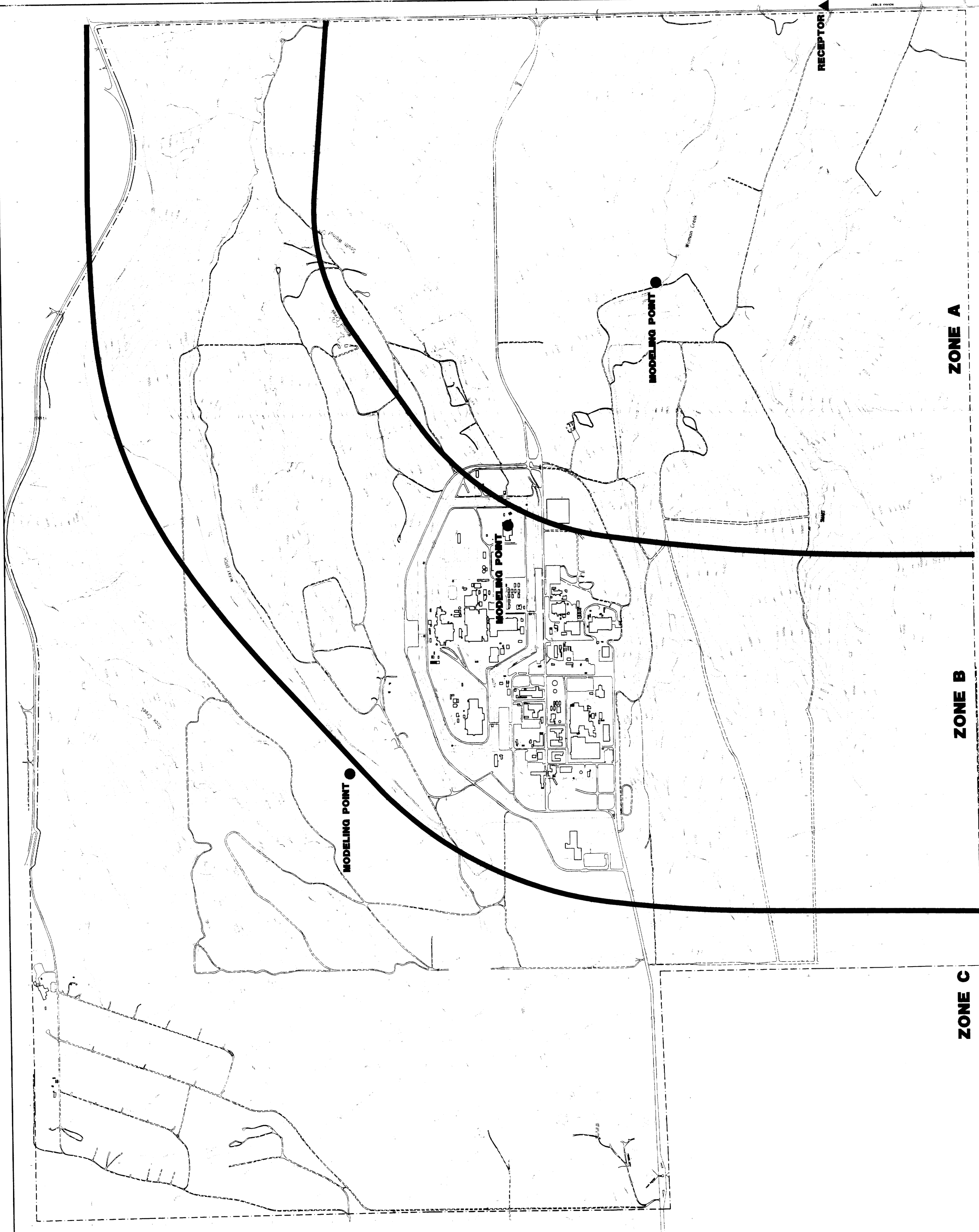
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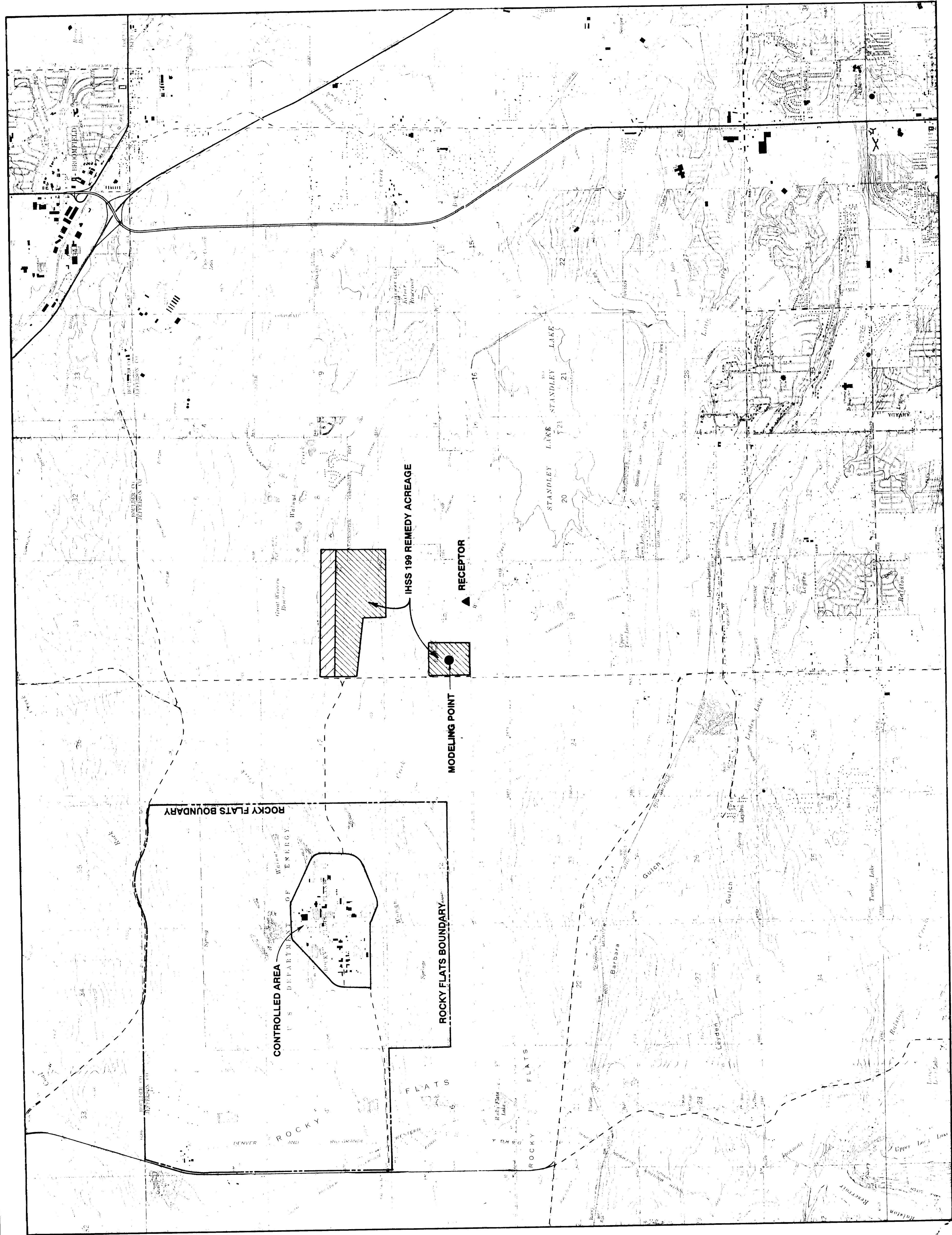
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0600-1900 HRS MST

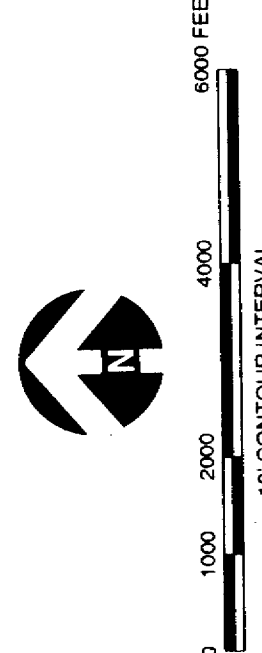
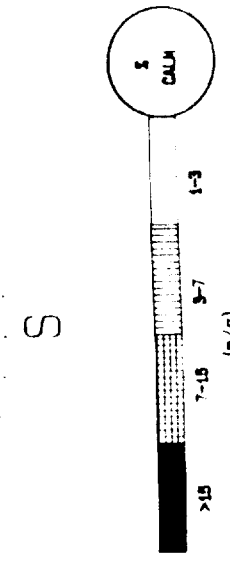
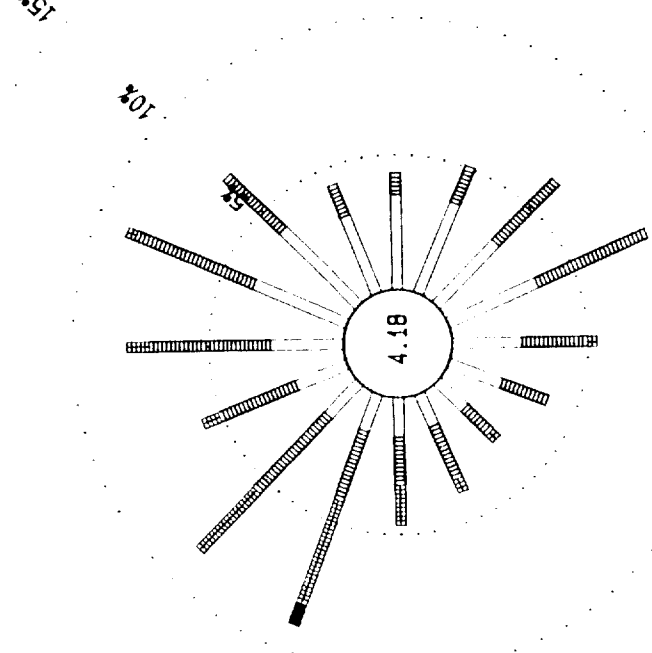


DRAWING 1 MODELING ZONES WITHIN ROCKY FLATS PLANT BOUNDARIES





N



DRAWING 2
OPERABLE UNIT 3
MODELING POINT AND
RECEPTOR